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ABSTRACT

This Occupational Competency Analysis Profile (OCAP), which is one of a series of OCAPs developed to identify the skills that Ohio employers deem necessary to entering a given occupation/occupational area, lists the occupational, academic, and employability skills required of individuals entering the occupation of precision machinist. The introduction explains the content and purpose of OCAPs. Presented next are an OCAP listing competency builders in 13 technical skill areas specific to precision machining (safety/equipment maintenance; measuring workpieces; drawing interpretation/layout/inspection; benchwork; power saws; drilling, grinding, milling, and turning machines; numerical control and computer numerical control machinery; conventional electrical discharge machining machines; heat-treating equipment; and advanced machining technology) and an OCAP listing competency builders in 12 employability skill categories. A section on academic job profiles discusses the purpose of job profiling, presents an academic job profile for precision machining, and details the specific academic skills included in the following categories: applied mathematics, locating information, reading for information, applied technology, teamwork, listening, and writing. Included in a section on academic competencies are a master list of 504 academic competencies and a list of 62 academic competencies specific to precision machining. Concluding the OCAP is information on the OCAP verification panels. (MN)

ED 386 551

OCAP

OCCUPATIONAL COMPETENCY ANALYSIS PROFILE

PRECISION MACHINING TECHNOLOGIES

U.S. DEPARTMENT OF EDUCATION
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Ohio's Future at Work

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Verification Panels ..... Inside back cover

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Introduction

What is an OCAP?

According to the *Action Plan for Accelerating the Modernization of Vocational Education: Ohio's Future at Work*—

> A comprehensive and verified employer competency list will be developed and kept current for each program
>
> —Imperative 3, Objective 2—

The Occupational Competency Analysis Profiles (OCAPs) are the Ohio Division of Vocational and Adult Education's response to that objective.

OCAPs are competency lists—verified by expert workers—that evolve from a modified DACUM job analysis process involving business, industry, labor, and community agency representatives from throughout Ohio. The OCAP process is directed by the Vocational Instructional Materials Laboratory located at The Ohio State University's Center on Education and Training for Employment.

How is the OCAP used?

Each OCAP identifies the occupational, academic, and employability skills (or competencies) needed to enter a given occupation or occupational area. The OCAP not only lists the *competencies* but also clusters those competencies into broader *units* and details the knowledge, skills, and attitudes (*competency builders*) needed to perform each competency.

Within the competency list are two levels of items: core and advancing. *Core items*, which are essential for entry-level employment, are required to be taught and are the basis for questions on the Ohio Vocational Competency Assessment (OVCA). *Advancing items* (marked with an asterisk) are those needed to advance in a given occupation.

School districts may add as many units, competencies, and/or competency builders as desired to reflect local employment needs, trends, and specialties. Local advisory committees should be actively involved in the identification and verification of additional items. Vocational and applied academic instructors will be able to formulate their courses of study using the varied contents of the OCAP and will be able to monitor competency gains via the new criterion-referenced competency testing program, which is tied to the competencies identified on the OCAP.

Notes

Occupational Competency Analysis Profile:

Precision Machining Technologies

Unit 1: Orientation

Competency 1.1: Maintain personal safety

Competency Builders:

1.1.1 Wear eye, ear, and respiratory protection according to Occupational Safety and Health Administration (OSHA) specifications
1.1.2 Wear hand and foot protection according to OSHA specifications
1.1.3 Wear clothing considered safe according to OSHA specifications
1.1.4 Confine long hair
1.1.5 Remove jewelry
1.1.6 Follow the established procedures for the use of fire extinguishers
1.1.7 Identify the location of fire alarms and exits
1.1.8 Report injuries to supervisor
1.1.9 Maintain work stations in accordance with standards for cleanliness and safety
1.1.10 Adhere to the directions given on material safety data sheet (MSDS) labels on hazardous materials
1.1.11 Interpret personal safety rights according to shop's Right-to-Know Plan

Competency 1.2: Maintain tools and equipment

Competency Builders:

1.2.1 Identify the general housekeeping and maintenance procedures for tools and equipment
1.2.2 Perform visual checks of grounding and cord condition on all machinery
1.2.3 Lock-out/tag-out mechanical equipment for repair and/or maintenance
1.2.4 Demonstrate the care and maintenance procedures for each hand tool and machine and related equipment
1.2.5 Check the mounting of all safety shields and/or machine guards for compliance with OSHA specifications
1.2.6 Store tools in accordance with shop policy

Competency 1.3: Demonstrate basic shop math skills

Competency Builders:

1.3.1 Apply basic math skills (e.g., addition, subtraction, multiplication, division, decimals, fractions)
1.3.2 Interpret tables and formulas in machinery handbooks
1.3.3 Manipulate simple formulas or algebraic equations
1.3.4 Perform calculations using right-angle trigonometric functions
1.3.5 Perform trigonometry calculations using a scientific hand calculator
1.3.6 Solve blueprint interpretive situations using shop math skills

Unit 2: Measuring Workpieces

Competency 2.1: Interpret different measuring systems

Competency Builders:

2.1.1 Demonstrate knowledge of the English system of measurement
2.1.2 Demonstrate knowledge of the metric system of measurement
2.1.3 Demonstrate knowledge of measurement standards and fit designations
2.1.4 Convert measurements from the metric to English system and vice versa

Competency 2.2: Use measuring tools

Competency Builders:

2.2.1 Demonstrate knowledge of the applications/functions of each basic measuring tool
2.2.2 Select the appropriate measuring tool for a given job
2.2.3 Make linear measurements using a steel rule
2.2.4 Measure inside diameter (ID) and outside diameter (OD) using inside, outside, or hermaphrodite calipers
2.2.5 Measure linear dimensions using dividers
2.2.6 Make a variety of measurements using a combination square
2.2.7 Check the accuracy of thread size and pitch using a thread pitch gage
2.2.8 Locate the center of a workpiece using a center gage
2.2.9 Check the accuracy of drill point angle using a drill point gage
2.2.10 Measure angles using a protractor
2.2.11 Measure depth for a groove hole, recess, or step using a depth gage
2.2.12 Check the accuracy of internal dimensions using a feeler gage
2.2.13 Check the accuracy of external and internal dimensions using plug and ring gages
2.2.14 Make very small internal measurements by transfer using a small-hole gage
2.2.15 Make very small internal measurements by transfer using a telescoping gage
2.2.16 Measure internal dimensions using an inside micrometer
2.2.17 Measure external dimensions using an outside micrometer
2.2.18 Measure internal and external dimensions and surface depth using vernier calipers
2.2.19 Measure internal and external dimensions and surface depth using a dial caliper
2.2.20 Measure the depth of a feature using a depth micrometer
2.2.21 Measure angular surfaces using a sine bar
2.2.22 Check sizes, measurements, and alignment against a known standard using a dial indicator
2.2.23 Check hole diameters and bores using a dial bore gage
2.2.24 Measure workpieces using a height gage
2.2.25 Verify instrument accuracy using Jo blocks
2.2.26 Maintain tools (e.g., clean, calibrate)
2.2.27 Demonstrate knowledge of the characteristics and functions of Go/No-Go gages
2.2.28 Demonstrate knowledge of the characteristics and functions of snap gages
2.2.29 Demonstrate knowledge of the characteristics and functions of taper plug gages
2.2.30 Demonstrate knowledge of the characteristics and functions of cylindrical squares
2.2.31 Demonstrate knowledge of the characteristics and functions of thread wires
2.2.32 Demonstrate knowledge of the characteristics and functions of universal bevel protractors
2.2.33 Demonstrate knowledge of the characteristics and functions of electronic measuring devices
2.2.34 Demonstrate knowledge of the characteristics and functions of optical comparators

Unit 3: Drawing Interpretation, Layout, and Inspection

Competency 3.1: Interpret blueprints

Competency Builders:

3.1.1 Identify the common drafting symbols
3.1.2 Identify the types of information found in the blueprint title block
3.1.3 Identify the types of views shown on blueprints
3.1.4 Identify the alphabet of lines
3.1.5 Interpret blueprint lines
3.1.6 Differentiate between object and hidden lines
3.1.7 Locate the needed views (top, front, side) of an object
3.1.8 Interpret section views
3.1.9 Identify the industry method for showing dimensions and tolerances
3.1.10 Identify the types and methods of screw thread representation
3.1.11 Identify the surface texture symbols and processes associated with them
3.1.12 Interpret the blueprint symbols commonly used in geometric dimensioning and tolerancing
3.1.13 Sketch workpieces

Competency 3.2: Perform basic layouts according to print specifications, dimensions, and tolerances

Competency Builders:

3.2.1 Lay out/transfer measurements using a combination square
3.2.2 Mark the center of round stock using the center head of a combination square
3.2.3 Lay out angles using the protractor head of a combination square
3.2.4 Layout/transfer measurements using a machinist's square
3.2.5 Lay out/transfer linear dimensions using a scriber, divider, and trammel
3.2.6 Lay out/transfer linear measurements using layout dye and a surface gage
3.2.7 Lay out angles using a sine bar
3.2.8 Locate positions using a center punch
3.2.9 Establish reference surfaces using a surface plate
3.2.10 Secure workpieces at variable heights above a surface plate using parallels
3.2.11 Secure workpieces at variable heights above a surface plate using a planer gage
3.2.12 Adjust position of parts using a layout hammer
3.2.13 Measure angular surfaces using angle gage blocks
3.2.14 Check sizes, measurements, and alignment against a known standard using a dial indicator
3.2.15 Verify instrument accuracy using Jo blocks
3.2.16 Secure workpieces in position using V-blocks
3.2.17 Secure workpieces in position using clamps
3.2.18 Secure workpieces in position using an angle plate

Competency 3.3: Check accuracy of parts

Competency Builders:

3.3.1 Inspect rectangular workpieces for compliance with print specifications, dimensions, and tolerances
3.3.2 Inspect round workpieces for compliance with print specifications, dimensions and tolerances
3.3.3 Inspect angular workpieces for compliance with print specifications, dimensions, and tolerances
3.3.4 Inspect internal dimensions for compliance with print specifications, dimensions, and tolerances

Unit 4: Benchwork

Competency 4.1: Use hand tools according to Occupational Safety and Health Administration (OSHA) specifications

Competency Builders:

4.1.1 Follow the established safety and maintenance procedures for hand tools
4.1.2 Select the work-holding device appropriate for a given job
4.1.3 Hold/turn fasteners using a wrench (e.g., open-end, box, socket, torque, adjustable, Allen, spanner)
4.1.4 Hold/turn fasteners using a screwdriver (e.g., flat-head, Phillips-head, offset)
4.1.5 Grip/hold small parts using pliers
4.1.6 Install hacksaw blades
4.1.7 Cut workpieces using a hacksaw
4.1.8 Cut metal by hand using a chisel (e.g., flat, cape, round-nose, gouge, diamond-point)
4.1.9 Shape/form metal using a ball-, straight-, or cross-peen hammer
4.1.10 Drive machined parts into place using a soft-face hammer
4.1.11 Drive pins, bolts, or parts using a pin punch
4.1.12 Transfer hole locations using a transfer punch
4.1.13 Transfer the location of threaded holes using transfer screws
4.1.14 Make cone-shaped indentations for centering layout work using a prick or center punch
4.1.15 Ream a hole using a reamer
4.1.16 Mark parts using handstamps
4.1.17 Finish materials using a file with a handle (e.g., machinists', precision)
4.1.18 Deburr workpieces using hand tools (e.g., file, scraper)
4.1.19 Hand-sharpen cutting tools
4.1.20 Identify the procedure for removing a broken bolt
4.1.21 Identify the procedure for removing a broken drill

Competency 4.2: Use hand power tools according to OSHA specifications

Competency Builders:

4.2.1 Follow the established safety and maintenance procedures for hand power tools
4.2.2 Drill holes using a hand power drill
4.2.3 Finish surfaces using a hand power grinder
4.2.4 Cut materials using an abrasive cutoff wheel

Competency 4.3: Cut threads using a tap and die

Competency Builders:

4.3.1 Identify thread uses
4.3.2 Identify the parts of a thread
4.3.3 Specify thread designations
4.3.4 Interpret thread designations
4.3.5 Measure screw pitch and diameter
4.3.6 Cut external threads using a die and die stock
4.3.7 Identify tap specifications
4.3.8 Cut internal threads using a tap and tap wrench

Competency 4.4: Use arbor presses

Competency Builders:

4.4.1 Identify the safety issues related to the use of arbor presses
4.4.2 Straighten bent workpieces using an arbor press
4.4.3 Assemble/disassemble workpieces using an arbor press
4.4.4 Broach keyways using a broaching set and arbor press
4.4.5 Select the tools needed in using the arbor press for assembly work

Competency 4.5: Demonstrate knowledge of the materials being machined

Competency Builders:

4.5.1 Interpret the terminology associated with materials and their machinability
4.5.2 Identify the types of metals and related materials
4.5.3 Distinguish between ferrous, nonferrous, and nonmetallic materials
4.5.4 Identify the heat-treating methods for use with various materials
4.5.5 Identify the factors that affect cutting speeds

Competency 4.6: Apply knowledge of heat-treating processes

Competency Builders

4.6.1 Interpret the terminology associated with heat treating
4.6.2 Identify the methods for testing the hardness and carbon content of steels
4.6.3 Test workpieces for hardness using various hardness testers
4.6.4 Select heat-treating processes

Unit 5: Power Saws

Competency 5.1: Perform preventive maintenance on power saws according to manufacturer's specifications

Competency Builders:

5.1.1 Follow the established safety procedures for power saw maintenance
5.1.2 Clean/lubricate power saws (e.g., cutoff, vertical band, horizontal cutoff, hacksaw)
5.1.3 Check power saws for wear and alignment
5.1.4 Check power saw blades for wear
5.1.5 Adjust coolant flow

Competency 5.2: Operate power saws according to manufacturer's specifications

Competency Builders:

5.2.1 Identify the various types of power saws
5.2.2 Identify the applications of various power saws
5.2.3 Identify the blade principles and configurations for power saws
5.2.4 Identify the factors that determine saw blade selection
5.2.5 Identify the speeds, feeds, and cutting fluids used with power saws
5.2.6 Identify the factors to consider in using cut-off saws
5.2.7 Identify the work-holding practices for cut-off saws
5.2.8 Select the power saw appropriate for a given job
5.2.9 Select the blade appropriate for a given job
5.2.10 Secure workpieces
5.2.11 Install blades
5.2.12 Follow the established break-in procedures for saw blades
5.2.13 Set cutting speeds and feeds using shop formulas and charts
5.2.14 Test-run blades to check alignment and direction
5.2.15 Cut material to length according to blueprint specifications
5.2.16 Cut straight lines
5.2.17 Make angular saw cuts
5.2.18 Make internal saw cuts*
5.2.19 Make contour saw cuts*
5.2.20 Contour saws to scribed lines*
5.2.21 Saw internal contours using a band saw*
5.2.22 Coil/uncoil band saw blades
5.2.23 Check the first piece for each job
5.2.24 Check parts in process
5.2.25 Adjust cutting fluid flow
5.2.26 Deburr workpieces
5.2.27 Inspect workpieces for compliance with engineering drawings and job specifications
5.2.28 Mark workpieces for future identification
5.2.29 Clean power saws after use
5.2.30 Cut blades
5.2.31 Weld blades
5.2.32 Store blades

Unit 6: Drilling Machines

Competency 6.1: Perform preventive maintenance on drilling machines according to manufacturer's specifications

Competency Builders:

6.1.1 Follow the established safety procedures for drilling machine maintenance
6.1.2 Clean/lubricate drilling machines
6.1.3 Check drilling machines for wear and alignment
6.1.4 Check drilling machine attachments for wear
6.1.5 Set coolant flow

Competency 6.2: Sharpen drill bits to specified geometry

Competency Builders:

6.2.1 Follow the established safety procedures for sharpening drill bits
6.2.2 Determine the drill geometry for material
6.2.3 Select the grinding wheel appropriate for a given sharpening task
6.2.4 Dress grinding wheels
6.2.5 Grind drill bits to drill gage

Competency 6.3: Mount workpieces

Competency Builders:

6.3.1 Identify the main types of work-holding devices
6.3.2 Select the work-holding device appropriate for a given job
6.3.3 Mount/align work-holding devices
6.3.4 Position workpieces using V-blocks
6.3.5 Secure workpieces
6.3.6 Perform the typical set-up for drilling in-round stock

Competency 6.4: Operate drilling machines according to manufacturer's specifications

Competency Builders:

6.4.1 Identify the major types of drilling machines and their uses
6.4.2 Identify the major parts of a drill press
6.4.3 Identify the cutting tools used for drill press operations
6.4.4 Select the drilling machine appropriate for a given job
6.4.5 Follow the shop safety guidelines for drilling machine operation
6.4.6 Set drilling feeds and speeds using shop formulas and charts
6.4.7 Change chucks and sleeves
6.4.8 Secure drills using a drill chuck and key
6.4.9 Secure drills using a drill drift
6.4.10 Set up coolants
6.4.11 Center drills
6.4.12 Drill workpieces to specified sizes
6.4.13 Ream holes
6.4.14 Counterbore holes
6.4.15 Countersink holes
6.4.16 Spot face holes
6.4.17 Power tap holes
6.4.18 Chamfer workpieces
6.4.19 Deburr/polish workpieces
6.4.20 Hone/lap workpieces
6.4.21 Inspect workpieces for compliance with engineering drawings and job specifications
6.4.22 Mark workpieces for future identification
6.4.23 Clean drilling machines

Unit 7: Grinding Machines

Competency 7.1: Demonstrate knowledge of the general maintenance procedures (manufacturer's specifications) for grinding machines

Competency Builders:

7.1.1 Identify the established safety procedures for grinding machine maintenance
7.1.2 Identify the general housekeeping and maintenance procedures for grinding machines
7.1.3 Identify the preventive maintenance procedures for grinding machines
7.1.4 Identify the tooling maintenance procedures for grinding machines
7.1.5 Identify the differences between the maintenance procedures for various grinding machines
7.1.6 Identify the procedures for the care of grinding wheels
7.1.7 Identify the procedures for the use of coolants with grinding machines

Competency 7.2: Demonstrate knowledge of grinding wheels and dressing devices

Competency Builders:

7.2.1 Identify the different types of conventional grinding wheels
7.2.2 Identify the specifications for conventional grinding wheels
7.2.3 Identify the different types of superabrasive grinding wheels
7.2.4 Identify the specifications for superabrasive grinding wheels
7.2.5 Identify the dressing procedures for conventional and superabrasive grinding wheels

Competency 7.3: Operate pedestal and/or bench grinders

Competency Builders:

7.3.1 Follow the established safety procedures for the use of pedestal or bench grinders
7.3.2 Select the grinding wheel appropriate for a given job
7.3.3 Mount grinding wheels
7.3.4 Identify the tools that can be sharpened on a grinder
7.3.5 Sharpen tools using pedestal and bench grinders
7.3.6 Clean the area in accordance with general practices

Competency 7.4 Operate tool and cutter grinders

Competency Builders:

7.4.1 Follow the established safety procedures for the use of tool and cutter grinders
7.4.2 Select the conventional grinding wheel appropriate for a given job
7.4.3 Mount grinding wheels
7.4.4 Select the dressing method appropriate for the wheel condition and given job
7.4.5 Dress grinding wheels
7.4.6 Select the work-holding device appropriate for a given job
7.4.7 Mount work-holding devices
7.4.8 Specify inspection methods
7.4.9 Set coolant flow
7.4.10 Grind tools
7.4.11 Inspect tools to verify tolerances and finish
7.4.12 Clean the area in accordance with general practices

Competency 7.5: Operate surface grinders

Competency Builders:

7.5.1 Follow the established safety procedures for the use of surface grinders
7.5.2 Select the conventional grinding wheel appropriate for a given job
7.5.3 Mount grinding wheels
7.5.4 Balance grinding wheels
7.5.5 Select the dressing method appropriate for the wheel condition and given job
7.5.6 Dress grinding wheels
7.5.7 Select the work-holding device appropriate for a given job
7.5.8 Mount work-holding devices
7.5.9 Specify inspection methods
7.5.10 Set coolant flow
7.5.11 Grind parts
7.5.12 Inspect parts to verify tolerances and finish
7.5.13 Clean the area in accordance with general practices

Competency 7.6: Operate outside diameter (OD) grinders

Competency Builders:

7.6.1 Follow the established safety procedures for the use of OD grinders
7.6.2 Select the conventional grinding wheel appropriate for a given job
7.6.3 Mount grinding wheels
7.6.4 Select the dressing method appropriate for the wheel condition and given job
7.6.5 Dress grinding wheels
7.6.6 Select the centers needed to grind a specified shaft
7.6.7 Install centers
7.6.8 Specify inspection methods
7.6.9 Set coolant flow
7.6.10 Grind outside diameter of shafts
7.6.11 Inspect shafts to verify tolerances and finish
7.6.12 Clean the area in accordance with general practices

Competency 7.7: Operate inside diameter (ID) grinders

Competency Builders:

7.7.1 Follow the established safety procedures for the use of ID grinders
7.7.2 Select the conventional grinding wheel appropriate for a given job
7.7.3 Mount grinding wheels
7.7.4 Select the dressing method appropriate for the wheel condition and given job
7.7.5 Dress grinding wheels
7.7.6 Select the work-holding device appropriate for a given job
7.7.7 Set coolant flow
7.7.8 Grind jaws to fit the outside diameter of parts*
7.7.9 Specify inspection methods
7.7.10 Grind the inside diameter of bushings
7.7.11 Inspect the inside diameter of bushings to verify tolerances and finish
7.7.12 Clean the area in accordance with general practices

Competency 7.8: Demonstrate basic knowledge of superabrasives*

Competency Builders:

7.8.1 Identify when to use superabrasives*
7.8.2 Identify the advantages of superabrasives*
7.8.3 Identify superabrasive dressing methods*
7.8.4 Identify the coolants used with superabrasives*

Unit 8: Milling Machines

Competency 8.1: Demonstrate basic knowledge of milling machines

Competency Builders:

8.1.1 Interpret the terminology associated with the milling machine
8.1.2 Identify the types of milling machines
8.1.3 Identify the major components of vertical milling machines
8.1.4 Identify milling machine horizontal operations
8.1.5 Identify milling machine vertical operations
8.1.6 Identify milling machine accessories for holding work
8.1.7 Identify milling machine accessories for holding cutting tools
8.1.8 Identify the parts of a horizontal knee-and-column mill

Competency 8.2: Apply knowledge of the general maintenance procedures (manufacturer's specifications) for milling machines

Competency Builders:

8.2.1 Follow the established safety procedures for milling machine maintenance
8.2.2 Identify the general housekeeping and maintenance procedures for milling machines
8.2.3 Identify the preventive maintenance procedures for milling machines
8.2.4 Identify the tooling maintenance procedures for milling machines
8.2.5 Clean/lubricate milling machines
8.2.6 Check milling machines for wear and alignment
8.2.7 Set coolant flow
8.2.8 Identify ANSI and ISO standards for the selection of cutter bodies and inserts
8.2.9 Identify the established procedures for setting up/operating milling machines with indexable tooling

Competency 8.3: Set up milling machines according to manufacturer's specifications

Competency Builders:

8.3.1 Select the milling machine appropriate for a given job
8.3.2 Indicate milling machine heads
8.3.3 Select the cutter appropriate for a given job
8.3.4 Mount tool holders and tools
8.3.5 Select speeds and feeds using shop formulas and charts
8.3.6 Select the work-holding device appropriate for a given job
8.3.7 Mount/indicate work-holding devices

Continued

Competency 8.3: ***Set up milling machines according to manufacturer's specifications—*** *Continued*

8.3.8 Mount/indicate workpieces
8.3.9 Select the cutting fluid appropriate for a given job
8.3.10 Calculate cutting speeds and spindle RPM
8.3.11 Calculate feed rates in inches or meters per minute
8.3.12 Align workpieces mounted on a machine table
8.3.13 Mount arbors
8.3.14 Adjust arbor support bushings on horizontal milling machines
8.3.15 Mount cutters and cutter holders for vertical spindle milling machines
8.3.16 Set up rotary tables

Competency 8.4: **Perform milling operations according to print specifications, dimensions, and tolerances**

Competency Builders:

8.4.1 Mill flat surfaces
8.4.2 Mill angular surfaces by tilting milling head
8.4.3 Mill cylindrical workpieces
8.4.4 Mill square workpieces mounted in a vise
8.4.5 Mill dovetails*
8.4.6 Mill external radiuses
8.4.7 Mill internal slots using a slotter and attachment*
8.4.8 Perform climb and conventional milling
8.4.9 Mill workpieces using a fly cutter
8.4.10 Mill to blueprint specifications using machine controls
8.4.11 Mill using power feed accessories
8.4.12 Identify the types of keyways
8.4.13 Calculate cut depths for keyways using standard formulas
8.4.14 Locate the cutter specifications for keyways
8.4.15 Mill keyways
8.4.16 Machine Woodruff keyways
8.4.17 Center drill on workpieces (vertical mill)
8.4.18 Drill holes using a vertical mill
8.4.19 Bore holes using a boring head
8.4.20 Tap workpieces
8.4.21 Ream workpieces
8.4.22 Pick up edges or scribed lines using an edgefinder or wiggler
8.4.23 Index work using a dividing head
8.4.24 Locate workpiece features in relation to one another using a rotary table
8.4.25 Secure workpieces in position using an angle plate
8.4.26 Measure angular surfaces using a sine plate
8.4.27 Monitor table movements using a digital readout accessory
8.4.28 Identify the uses and components of indexing heads*
8.4.29 Identify the uses and limitations of direct indexing devices*
8.4.30 Mill workpieces using an indexing head
8.4.31 Identify the types of gears
8.4.32 Identify the applications of different types of gears

Continued

Competency 8.4: ***Perform milling operations according to print specifications, dimensions, and tolerances—Continued***

8.4.33 Calculate gear variables using formulas*
8.4.34 Cut gears (e.g., spur gears)*
8.4.35 Measure gears using a vernier gear caliper*
8.4.36 Perform cutting-off operations
8.4.37 Perform slab milling operations

Unit 9: Lathes and Turning Machines

Competency 9.1: Demonstrate basic knowledge of lathes

Competency Builders:

9.1.1 Interpret the terminology associated with lathes
9.1.2 Identify the types of lathes
9.1.3 Identify the parts and subparts of a lathe
9.1.4 Identify the applications of specific lathe accessories

Competency 9.2: Demonstrate knowledge of the general maintenance procedures (manufacturer's specifications) for lathes and turning machines

Competency Builders:

9.2.1 Identify the established safety procedures for lathe and turning machine maintenance
9.2.2 Identify the general housekeeping and maintenance procedures for lathes and turning machines
9.2.3 Identify the preventive maintenance procedures for lathes and turning machines
9.2.4 Identify the tooling maintenance procedures for lathes and turning machines
9.2.5 Identify the procedures for the use of coolants with lathes and turning machines

Competency 9.3: Grind cutting tools

Competency Builders:

9.3.1 Select the grinding machine and wheel type appropriate for a given job
9.3.2 Select the tool blank appropriate for a given job
9.3.3 Grind tool blanks to specified geometry
9.3.4 Differentiate between hand-ground and insert-type tooling geometries

Competency 9.4: Set up turning operations

Competency Builders:

9.4.1 Identify the common turning operations
9.4.2 Identify the basic shapes of indexable/single-point cutting tools
9.4.3 Compare the advantages and disadvantages of carbide and high-speed steel cutting tools
9.4.4 Follow the established safety procedures for the use of lathes and various turning machines
9.4.5 Select the work-holding device appropriate for a given job
9.4.6 Mount work-holding devices (chuck, face plate, collets) *Continued*

Competency 9.4: ***Set up turning operations****—Continued*

9.4.7 Demonstrate the methods for mounting workpieces between centers and onto mandrels
9.4.8 Secure workpieces
9.4.9 Identify types of tool posts and toolholders and their uses
9.4.10 Select toolholders and inserts according to ANSI and ISO standards
9.4.11 Mount toolholders
9.4.12 Set up/operate turning machines with indexable tooling
9.4.13 Set turning feeds and speeds using shop formulas and charts
9.4.14 Select the type of carbide to match a given application

Competency 9.5: **Perform turning operations according to print specifications, dimensions, and tolerances**

Competency Builders:

9.5.1 Mount/true workpieces in 3-jaw and 4-jaw chucks
9.5.2 Mount workpieces between centers
9.5.3 Mount workpieces on faceplates
9.5.4 Mount workpieces in collets
9.5.5 Align centers
9.5.6 Face workpieces
9.5.7 Turn outside diameters
9.5.8 Turn workpieces to a shoulder
9.5.9 Turn inside diameter (ID) and outside diameter (OD) tapers
9.5.10 Knurl workpieces
9.5.11 Cut off workpieces using a parting tool
9.5.12 Cut workpieces using a form tool
9.5.13 Bore inside diameters
9.5.14 Cut right-hand and left-hand threads
9.5.15 Center-drill workpieces
9.5.16 Drill workpieces
9.5.17 Support long workpieces using a steady rest
9.5.18 Support long workpieces using a follower rest
9.5.19 Ream workpieces
9.5.20 Counterbore holes
9.5.21 Countersink holes
9.5.22 Chamfer workpieces
9.5.23 File/polish workpieces
9.5.24 Cut double-lead screws*
9.5.25 Turn hardened parts using ceramics*
9.5.26 Produce tapers
9.5.27 Perform tapping operations using a lathe
9.5.28 Pick up threads using a lathe
9.5.29 Sharpen cutoff tool blades

Competency 9.6: Set up turret turning machines according to manufacturer's specifications

Competency Builders:

9.6.1 Select the sequence in which tools will be used
9.6.2 Mount tools on turret
9.6.3 Check the swing radius for tool clearance
9.6.4 Differentiate between types of work-holding methods
9.6.5 Set up various machine stops

Competency 9.7: Apply cutting fluids

Competency Builders:

9.7.1 Identify the influences and functions of cutting fluids
9.7.2 Identify the major types of cutting fluids and general rules for their use
9.7.3 Select the cutting fluid appropriate for a given job
9.7.4 Direct flow of cutting fluid on workpieces

Competency 9.8: Inspect workpieces

Competency Builders:

9.8.1 Deburr workpieces
9.8.2 Inspect workpieces for compliance with engineering drawings and job specifications
9.8.3 Mark workpieces for future identification
9.8.4 Clean the area in accordance with general practices

Unit 10: Numerical Control (NC) and Computer Numerical Control (CNC) Machinery

Competency 10.1: Demonstrate basic knowledge of NC and CNC machines

Competency Builders

10.1.1 Identify the advantages and disadvantages of using NC and CNC machines for different jobs
10.1.2 Identify the basic components of NC and CNC machine tools
10.1.3 Calculate coordinates and dimensions for NC and CNC machines
10.1.4 Solve NC/CNC problems using simple trigonometry

Competency 10.2: Prepare programs according to print specifications, dimensions, and tolerances

Competency Builders:

10.2.1 Demonstrate knowledge of the basic functions of a computer
10.2.2 Demonstrate knowledge of the basics of data transfer (e.g., uploading and downloading of information)
10.2.3 Demonstrate knowledge of the basics of conversational programming
10.2.4 Write programs in EIA-ISO formats
10.2.5 Program using CAD/CAM systems

Competency 10.3: Set up/operate CNC grinding machines*

Competency Builders:

10.3.1 Follow the established safety procedures for the use of CNC grinding machines*
10.3.2 Identify the parts of a grinder (e.g., utility, pedestal)*
10.3.3 Identify set-up techniques and considerations*
10.3.4 Identify grinding wheels using the established numbering system*
10.3.5 Inspect grinding wheels*
10.3.6 Identify dressing and truing techniques*
10.3.7 Identify relieving and side dressing techniques*
10.3.8 Check angle dressing using angle gage blocks*
10.3.9 Lubricate CNC grinding machines*
10.3.10 Check CNC grinding machines for wear and alignment *
10.3.11 Write programs in word address format*
10.3.12 Set tooling references*
10.3.13 Dry-run CNC grinding machines*
10.3.14 Set coolant flow*
10.3.15 Specify inspection methods*
10.3.16 Grind parts using CNC machines*
10.3.17 Inspect parts to verify tolerances and finish*
10.3.18 Clean the area in accordance with general practices*

Competency 10.4: Set up/operate CNC milling machines*

Competency Builders:

10.4.1 Follow the established safety procedures for the use of CNC milling machines*
10.4.2 Lubricate CNC milling machines*
10.4.3 Check CNC milling machines for wear and alignment*
10.4.4 Write programs in word address format*
10.4.5 Set tooling references*
10.4.6 Dry-run CNC milling machines*
10.4.7 Set coolant flow*
10.4.8 Specify inspection methods*
10.4.9 Mill parts using CNC milling machines*
10.4.10 Inspect parts to verify tolerances and finish*
10.4.11 Clean the area in accordance with general practices*

Competency 10.5: Set up/operate CNC turning machines*

Competency Builders:

10.5.1 Follow the established safety procedures for the use of CNC turning machines*
10.5.2 Lubricate CNC turning machines*
10.5.3 Check CNC turning machines for wear and alignment*
10.5.4 Write programs in word address format*
10.5.5 Set tooling references*
10.5.6 Dry-run CNC turning machines*
10.5.7 Set coolant flow*
10.5.8 Specify inspection methods*
10.5.9 Turn parts using CNC turning machines*
10.5.10 Inspect parts to verify tolerances and finish*
10.5.11 Clean the area in accordance with general practices*

Unit 11: Conventional Electrical Discharge Machining (EDM) Machines

Competency 11.1: Apply knowledge of the general maintenance procedures (manufacturer's specifications) for EDM machines

Competency Builders:

11.1.1 Follow the established safety procedures for the maintenance of EDM machines
11.1.2 Identify the general housekeeping and maintenance procedures for EDM machines
11.1.3 Identify the preventive maintenance procedures for EDM machines
11.1.4 Identify the tooling maintenance procedures for EDM machines
11.1.5 Identify the procedures for the use of dielectric fluids with EDM machines
11.1.6 Clean/lubricate EDM machines
11.1.7 Check EDM machines for wear and alignment

Competency 11.2: Prepare electrodes according to manufacturer's specifications

Competency Builders:

11.2.1 Identify the types of electrode material
11.2.2 Select the electrode material appropriate for a given job
11.2.3 Follow the established safety procedures for machining electrodes
11.2.4 Determine the flushing technique to be used

Competency 11.3: Set up EDM machines according to manufacturer's specifications

Competency Builders:

11.3.1 Mount electrodes
11.3.2 Select the work-holding device appropriate for a given job
11.3.3 Mount work-holding devices
11.3.4 Mount/secure workpieces
11.3.5 Set machine controls to workpiece and electrode specifications

Competency 11.4: Operate EDM machines according to print specifications, dimensions, and tolerances

Competency Builders:

11.4.1 Adjust dielectric fluid levels
11.4.2 Set flushing systems
11.4.3 Spark-in electrodes
11.4.4 Burn parts
11.4.5 Inspect parts

Unit 12: Heat-Treating Equipment

Competency 12.1: Perform preventive maintenance on heat-treating equipment according to manufacturer's specifications*

Competency Builders:

12.1.1 Follow the established safety procedures for the maintenance of heat-treating equipment*
12.1.2 Inspect heat-treating equipment*
12.1.3 Clean heat-treating equipment*
12.1.4 Check quenching tank for coolant type and level*
12.1.5 Identify the types of furnaces*

Competency 12.2: Use heat-treating equipment for different processes according to manufacturer's specifications and print specifications, dimensions, and tolerances*

Competency Builders:

12.2.1 Harden carbon steel workpieces*
12.2.2 Temper carbon steel workpieces*
12.2.3 Flame-harden workpieces*
12.2.4 Case-harden low-carbon workpieces*
12.2.5 Anneal workpieces*
12.2.6 Normalize workpieces*

Competency 12.3: Harden materials

Competency Builders:

12.3.1 Interpret the terminology related to heat treating
12.3.2 Identify the methods for testing the hardness and carbon content of steels
12.3.3 Identify the factors that affect cutting speeds and tool-bit geometry
12.3.4 Identify the carbon content of steel using the SAE/AISI numbering systems
12.3.5 Correlate types of materials to properties
12.3.6 Test workpieces for hardness without a hardness tester
12.3.7 Follow the established safety procedures for operating heat-treating equipment
12.3.8 Perform heat-treating processes

Unit 13: Advanced Machining Technology*

Competency 13.1: Investigate the use wire electrical discharge machining (EDM)*

Competency Builders:

13.1.1 Identify the applications of wire EDM*
13.1.2 Explain the operational principles of wire EDM machines*
13.1.3 Identify the major components of wire EDM machines*
13.1.4 Explain the cost advantages of EDM processes*
13.1.5 Explain the machining advantages of EDM processes*

Competency 13.2: Investigate the use of laser beam machining (LBM)*

Competency Builders:

13.2.1 Identify the applications of LBM*
13.2.2 Explain the operational principles of LBM machines*
13.2.3 Identify the major components of LBM machines*
13.2.4 Explain the cost advantages of LBM processes*
13.2.5 Explain the machining advantages of LBM processes*

Competency 13.3: Investigate the use of plasma beam (arc) machining (PBM)*

Competency Builders:

13.3.1 Identify the applications of PBM*
13.3.2 Explain the operational principles of PBM equipment*
13.3.3 Identify the major components of PBM equipment*
13.3.4 Explain the cost advantages of PBM processes*
13.3.5 Explain the machining advantages of PBM processes*

Competency 13.4: Investigate the use of water-jet cutting*

Competency Builders:

13.4.1 Identify the applications of water-jet cutting*
13.4.2 Explain the operational principles of water jet cutting equipment*
13.4.3 Identify the major components of water-jet cutting equipment*
13.4.4 Explain the cost advantages of water-jet cutting processes*
13.4.5 Explain the machining advantages of water-jet cutting processes*

Competency 13.5: Investigate the use of electrochemical machining (ECM)*

Competency Builders:

13.5.1 Identify the applications of ECM*
13.5.2 Explain the operational principles of ECM machines*
13.5.3 Identify the major components of ECM machines*
13.5.4 Explain the cost advantages of ECM processes*
13.5.5 Explain the machining advantages of ECM processes*

Notes

Occupational Competency Analysis Profile:

Employability

Unit 1: Career Development

Competency 1.1: Investigate career options

Competency Builders:

1.1.1 Determine interests and aptitudes
1.1.2 Identify career options
1.1.3 Research interests, knowledge, abilities, and skills needed in an occupation
1.1.4 Select careers that best match interests and aptitudes
1.1.5 Identify advantages and disadvantages of career options, including self-employment and nontraditional careers

Competency 1.2: Utilize career information

Competency Builders:

1.2.1 Identify a range of career information resources
1.2.2 Use a range of resources to obtain career information (e.g., handbooks, career materials, labor market information, and computerized career-information delivery systems)
1.2.3 Demonstrate knowledge of various classification systems that categorize occupations and industries (e.g., *Dictionary of Occupational Titles*)
1.2.4 Describe the educational requirements of various occupations
1.2.5 Identify individuals in selected occupations as possible information resources, role models, or mentors
1.2.6 Describe the impact of factors such as population, climate, employment trends, and geographic location on occupational opportunities
1.2.7 Assess differences in the wages, benefits, annual incomes, cost of living, and job opportunties associated with selected career options
1.2.8 Determine labor market projections for selected career options

Competency 1.3: Participate in a career exploration activity

Competency Builders:

1.3.1 Identify career exploration activities (e.g., job shadowing, mentoring, volunteer experiences, part-time employment, and cooperative education)
1.3.2 Compare traits, skills, and characteristics required for specific career choices with individual's traits, skills, and characteristics
1.3.3 Recognize potential conflicts between personal characteristics and career choice areas
1.3.4 Describe the impact of exploration activities on current career choices

Competency 1.4: Assess the relationship between educational achievement and career planning

Competency Builders:

1.4.1 Describe how skills developed in academic and vocational programs relate to career goals
1.4.2 Describe how education relates to the selection of a college major, further training, and/or entry into the job market
1.4.3 Identify skills that can apply to a variety of occupational requirements
1.4.4 Explain the importance of possessing learning skills in the workplace

Competency 1.5: Develop an individual career plan

Competency Builders:

1.5.1 Identify career goal(s)
1.5.2 Identify worker conditions, education, training, and employment opportunities related to selected career goal(s)
1.5.3 Describe school and community resources available to help achieve career goal(s)
1.5.4 Identify career ladders possible within selected career goal(s)*
1.5.5 Identify additional experiences needed to move up identified career ladders*
1.5.6 Recognize that changes may require retraining and upgrading of employees' skills

Competency 1.6: Annually review/revise the individual career plan

Competency Builders:

1.6.1 Identify experiences that have reinforced selection of the specific career goal(s) listed on the individual career plan
1.6.2 Identify experiences that have changed the specific career goal(s) listed on the individual career plan
1.6.3 Modify the career goals(s) and educational plans on the individual career plan
1.6.4 Ensure that parents or guardians provide input into the individual career plan process
1.6.5 Identify the correlation between the individual career plan and the actual courses to be taken in high school
1.6.6 Identify the correlation between the individual career plan and postsecondary training, adult education, or employment

Unit 2: Decision Making and Problem Solving

Competency 2.1: Apply decision-making techniques in the workplace

Competency Builders:

2.1.1 Identify the decision to be made
2.1.2 Compare alternatives
2.1.3 Determine the consequences of each alternative
2.1.4 Make decisions based on values and goals
2.1.5 Evaluate the decision made

Competency 2.2: Apply problem-solving techniques in the workplace

Competency Builders:

2.2.1 Diagnose the problem, its urgency, and its causes
2.2.2 Identify alternatives and their consequences in relation to the problem
2.2.3 Recognize multicultural and nonsexist dimensions of problem solving
2.2.4 Explore possible solutions to the problem using a variety of resources
2.2.5 Compare/contrast the advantages and disadvantages of each solution
2.2.6 Determine appropriate action
2.2.7 Implement action
2.2.8 Evaluate results of action implemented

Unit 3: Work Ethic

Competency 3.1: Evaluate the relationship of self-esteem to work ethic

Competency Builders:

3.1.1 Identify special characteristics and abilities in self and others
3.1.2 Identify internal and external factors that affect self-esteem
3.1.3 Identify how individual characteristics relate to achieving personal, social, educational, and career goals
3.1.4 Identify the relationship between personal behavior and self-concept

Competency 3.2: Analyze the relationship of personal values and goals to work ethic both in and out of the workplace

Competency Builders:

3.2.1 Distinguish between values and goals
3.2.2 Determine the importance of values and goals
3.2.3 Evaluate how one's values affect one's goals
3.2.4 Identify own short- and long-term goals
3.2.5 Prioritize own short- and long-term goals
3.2.6 Identify how one's values are reflected in one's work ethic
3.2.7 Identify how interactions in the workplace affect one's work ethic
3.2.8 Identify how life changes affect one's work ethic

Competency 3.3: Demonstrate work ethic

Competency Builders:

3.3.1 Examine factors that influence work ethic
3.3.2 Display initiative
3.3.3 Demonstrate dependable attendance and punctuality
3.3.4 Demonstrate organizational skills
3.3.5 Adhere to schedules and deadlines
3.3.6 Demonstrate a willingness to learn
3.3.7 Demonstrate a willingness to accept feedback and evaluation
3.3.8 Demonstrate interpersonal skills required for working with and for others
3.3.9 Describe appropriate employer-employee interactions for various situations
3.3.10 Express feelings and ideas in an appropriate manner for the workplace

Competency 3.4: Demonstrate safety skills

Competency Builders:

3.4.1 Practice safe work habits
3.4.2 Identify safety hazards
3.4.3 Employ preventative safety measures
3.4.4 Demonstrate appropriate care and use of equipment and facilities to ensure safety
3.4.5 Comply with safety and emergency procedures

Unit 4: Job-Seeking Skills

Competency 4.1: Prepare for employment

Competency Builders:

4.1.1 Identify traditional and nontraditional employment sources
4.1.2 Utilize employment sources
4.1.3 Research job opportunities, including nontraditional careers
4.1.4 Interpret equal employment opportunity laws
4.1.5 Explain the critical importance of personal appearance, hygiene, and demeanor throughout the employment process
4.1.6 Prepare for generic employment tests and those specific to an occupation/organization

Competency 4.2: Develop a résumé

Competency Builders:

4.2.1 Identify personal strengths and weaknesses
4.2.2 List skills and/or abilities, career objective(s), accomplishments/achievements, educational background, work experience, volunteer/community contributions, and organizational memberships
4.2.3 Select an acceptable résumé format
4.2.4 Use correct grammar and spelling and concise wording
4.2.5 Secure references
4.2.6 Complete the résumé

Competency 4.3: Complete the job application process

Competency Builders:

4.3.1 Explain the importance of an application form
4.3.2 Obtain job application forms
4.3.3 Demonstrate appropriate behaviors (e.g., personal appearance, hygiene, and demeanor) for obtaining job application forms in person
4.3.4 Describe methods for handling illegal questions on job application forms
4.3.5 Demonstrate legible written communication skills using correct grammar and spelling and concise wording
4.3.6 Return application to appropriate person
4.3.7 Request interview
4.3.8 Follow up on application status

Competency 4.4: Demonstrate interviewing skills

Competency Builders:

4.4.1 Investigate interview procedures
4.4.2 Demonstrate appropriate behaviors (e.g. appearance, hygiene, and demeanor) for the interview
4.4.3 Demonstrate question-and-answer techniques
4.4.4 Demonstrate methods for handling difficult and/or illegal interview questions
4.4.5 Use correct grammar and concise wording

Competency 4.5: Secure employment

Competency Builders:

4.5.1 Identify present and future employment opportunities within an occupation/organization
4.5.2 Research the organization/company
4.5.3 Use follow-up techniques to enhance employment potential
4.5.4 Evaluate job offer(s)
4.5.5 Respond to job offer(s)

Unit 5: Job Retention and Career Advancement Skills

Competency 5.1: Analyze the organizational structure of the workplace

Competency Builders:

5.1.1 Identify employer expectations regarding job performance, work habits, attitudes, personal appearance, and hygiene
5.1.2 Comply with company policies and procedures
5.1.3 Examine the role/relationship between employee and employer
5.1.4 Recognize opportunities for advancement and reasons for termination
5.1.5 Recognize the organization's ethics.

Competency 5.2: Maintain positive relations with others

Competency Builders:

5.2.1 Exhibit appropriate work habits and attitudes
5.2.2 Identify behaviors for establishing successful working relationships
5.2.3 Cooperate through teamwork and group participation
5.2.4 Demonstrate a willingness to compromise
5.2.5 Identify methods for dealing with harassment, bias, and discrimination based on race, color, national origin, gender, religion, disability, or age
5.2.6 Cooperate with authority
5.2.7 Accept supervision

Competency 5.3: Demonstrate accepted social and work behaviors

Competency Builders

5.3.1 Demonstrate a positive attitude
5.3.2 Demonstrate accepted conversation skills
5.3.3 Use good manners
5.3.4 Accept responsibility for assigned tasks
5.3.5 Demonstrate personal hygiene
5.3.6 Demonstrate knowledge of a position
5.3.7 Perform quality work

Competency 5.4: Analyze opportunities for personal and career growth*

Competency Builders:

5.4.1 Determine opportunities within chosen occupation/organization*
5.4.2 Determine other career opportunities outside chosen occupation/ organization*
5.4.3 Evaluate the factors involved in considering a new position within or outside an occupation/ organization*
5.4.4 Exhibit characteristics needed for advancement*

Unit 6: Technology in the Workplace

Competency 6.1: Demonstrate knowledge of technology issues

Competency Builders:

6.1.1 Demonstrate knowledge of the characteristics of technology
6.1.2 Demonstrate knowledge of how technology systems are applied
6.1.3 Assess the impact of technology on the individual, society, and environment
6.1.4 Demonstrate knowledge of the evolution of technology
6.1.5 Identify how people, information, tools and machines, energy, capital, physical space, and time influence the selection and use of technology
6.1.6 Identify legal and ethical issues related to technology (e.g., confidentiality, information sharing, copyright protection)

Competency 6.2: Demonstrate skills related to technology issues

Competency Builders:

6.2.1 Exhibit willingness to adapt to technological change
6.2.2 Utilize technological systems
6.2.3 Utilize a variety of resources and processes to solve technological problems
6.2.4 Employ higher-order thinking skills for solving technological problems
6.2.5 Work as a team member in solving technological problems
6.2.6 Use technology in a safe and responsible manner
6.2.7 Apply science, mathematics, communication, and social studies concepts to solve technological problems
6.2.8 Demonstrate ingenuity and creativity in the use of technology*
6.2.9 Utilize a formal method (systems approach) in solving technological problems*

Unit 7: Lifelong Learning

Competency 7.1: Apply lifelong learning practices to individual situations

Competency Builders:

7.1.1 Define lifelong learning
7.1.2 Identify factors that cause the need for lifelong learning
7.1.3 Identify changes that may require the retraining and upgrading of employee's skills
7.1.4 Identify avenues for lifelong learning
7.1.5 Participate in lifelong learning activities

Competency 7.2: Adapt to change

Competency Builders:

7.2.1 Analyze the causes and effects of change
7.2.2 Identify the effect of change on goals
7.2.3 Identify the importance of flexibility when reevaluating goals
7.2.4 Evaluate the need for lifelong learning experiences in adapting to change

Unit 8: Economic Education

Competency 8.1: Analyze how an economy functions as a whole

Competency Builders:

8.1.1 Describe how individuals and societies make choices to satisfy needs and wants with limited resources
8.1.2 Identify how production factors (land, labor, capital, and entrepreneurship) are used to produce goods and services
8.1.3 Illustrate how individuals and households exchange their resources for the income they use to buy goods and services
8.1.4 Explain how individuals and business firms use resources to produce goods and services to generate income
8.1.5 Identify characteristics of command, market, and traditional economies*
8.1.6 Describe how all levels of government assess taxes in order to provide services

Competency 8.2: Analyze how an economic system is a framework within which decisions are made by individuals and groups

Competency Builders:

8.2.1 List several individuals and groups that make economic decisions at the local, state, and national levels
8.2.2 Identify the important roles that local, state, and national governments play in a market economy

Continued

Competency 8.2: ***Analyze how an economic system is a framework within which decisions are made by individuals and groups****—Continued*

8.2.3 List examples of how government decisions affect individuals
8.2.4 Identify how geographic locations affect the political and economic systems of the world
8.2.5 Evaluate how markets allocate goods and services
8.2.6 Explain how resources, goods, and services are exchanged in markets
8.2.7 Explain competition and its effect on the market

Competency 8.3: Analyze the importance of making informed personal financial decisions

Competency Builders:

8.3.1 Describe the need for personal management records
8.3.2 Create a personal budget
8.3.3 Create a budget for a family of four for one month
8.3.4 Explain how credit affects personal/family finances
8.3.5 Identify steps to avoid credit problems
8.3.6 Make informed consumer choices in response to personal needs and wants
8.3.7 Identify factors that influence consumer decisions (e.g., advertisements, peer groups, price, and location)
8.3.8 Explain the costs and benefits for individuals of various types of taxation at the local, state, and federal levels

Unit 9: Balancing Work and Family

Competency 9.1: Analyze the effects of family on work

Competency Builders:

9.1.1 Recognize how family values, goals, and priorities are reflected in the workplace
9.1.2 Identify present and future family structures and responsibilities
9.1.3 Describe personal and family roles
9.1.4 Analyze concerns of working parent(s)
9.1.5 Examine how family responsibilities can conflict with work
9.1.6 Identify ways to resolve family-related conflicts
9.1.7 Explain how to use support systems/community resources to help resolve family-related conflicts

Competency 9.2: Analyze the effects of work on family

Competency Builders:

9.2.1 Identify responsibilities associated with paid and nonpaid work
9.2.2 Compare the advantages and disadvantages of multiple incomes
9.2.3 Explain how work can conflict with family responsibilities
9.2.4 Explain how work-related stress can affect families
9.2.5 Identify family support systems and resources

Unit 10: Citizenship in the Workplace

Competency 10.1: Exercise the rights and responsibilities of citizenship in the workplace

Competency Builders:

10.1.1 Identify the basic rights and responsibilities of citizenship in the workplace
10.1.2 Identify situations in which compromise is necessary
10.1.3 Examine how individuals from various backgrounds contribute to the workplace
10.1.4 Demonstrate initiative to facilitate cooperation
10.1.5 Give/receive constructive criticism to enhance cooperation

Competency 10.2: Prepare to work in a multicultural society

Competency Builders:

10.2.1 Identify ways to live in a multicultural society with mutual respect and appreciation for others
10.2.2 Examine how culture and experience create differences in people
10.2.3 Demonstrate respect for the contributions made by all people
10.2.4 Investigate personal cultural background as a means of developing self-respect
10.2.5 Make personal choices that reduce discrimination, isolation, and prejudice
10.2.6 Work effectively with people irrespective of their race, gender, religion, ethnicity, disability, age, or cultural background

Unit 11: Leadership

Competency 11.1: Evaluate leadership styles appropriate for the workplace

Competency Builders:

11.1.1 Identify characteristics of effective leaders
11.1.2 Compare leadership styles
11.1.3 Demonstrate effective delegation skills
11.1.4 Investigate empowerment concepts
11.1.5 Identify opportunities to lead in the workplace

Competency 11.2: Demonstrate effective teamwork skills

Competency Builders:

11.2.1 Identify the characteristics of a valuable team member
11.2.2 Identify methods of involving each team member
11.2.3 Contribute to team efficiency and success
11.2.4 Determine ways to motivate team members

Competency 11.3: Utilize effective communication skills

Competency Builders:

11.3.1 Identify the importance of listening
11.3.2 Demonstrate effective listening skills
11.3.3 Demonstrate assertive communication techniques
11.3.4 Recognize the importance of verbal and nonverbal cues and messages
11.3.5 Prepare written material
11.3.6 Analyze written material
11.3.7 Give/receive feedback
11.3.8 Communicate thoughts
11.3.9 Use appropriate language
11.3.10 Follow oral and written instructions
11.3.11 Demonstrate effective telephone techniques
11.3.12 Identify technology in communications

Unit 12: Entrepreneurship

Competency 12.1: Evaluate the role of small business

Competency Builders:

12.1.1 Identify the impact of small business on the local economy
12.1.2 Examine the relationship of small business to a national (USA) and global economy
12.1.3 Identify factors that contribute to the success of small business
12.1.4 Identify factors that contribute to the failure of small business
12.1.5 Identify the components of a business plan

Competency 12.2: Examine entrepreneurship as a personal career option

Competency Builders:

12.2.1 Evaluate personal interests and skills
12.2.2 Compare personal interests and skills with those necessary for entrepreneurship
12.2.3 Determine motives for becoming an entrepreneur
12.2.4 Identify the advantages and disadvantages of owning a small business
12.2.5 Compare business ownership to working for others

Notes

Academic Job Profile

The Purpose of Job Profiling

Developed by American College Testing (ACT), the purpose of the Job Profiling process is to identify the **level** of applied academic skills that, according to business and industry, students must master to qualify for and be successful in their occupation of choice. The results of Job Profile "leveling" can help teachers to better target instruction toward their students' needs.

As part of the Ohio Vocational Competency Assessment (OVCA) program, the Vocational Instructional Materials Laboratory (VIML) at The Ohio State University has conducted Job Profiling workshops in which representatives of business, industry, labor, and community organizations identified the academic skill levels needed by entry-level workers in the occupational areas covered by the OCAPs. The Job Profiling, which was carried out in fall 1994 and spring 1995, was sponsored by the Ohio Department of Education, Division of Vocational and Adult Education.

OVCA—What Is It?

The Ohio Vocational Competency Assessment (or OVCA) package consists of two assessment components: OCAP and Work Keys. Together they measure entry-level occupational, academic, and employability skills. All OVCA items are criterion-referenced, use a multiple-choice format, and are administered using a traditional paper-and-pencil method. The OVCA is designed to do the following:

- Provide one dimension of a multi-assessment strategy for career passport credentialing
- Evaluate learner readiness for jobs requiring specific occupational, academic, and employability skills
- Assist educators in curriculum development
- Provide state-aggregated learning gain scores to comply with regulations in the Carl D. Perkins Vocational and Applied Technology Act of 1992

OCAP. The OCAP component of OVCA assesses students in occupational skills—employment requirements—in a particular occupational area. Assessment is based on the core competencies identified through the OCAP process, and each multiple-choice assessment item is correlated to those essential competencies.

Work Keys. The Work Keys component, developed by ACT, measures students' applied academic skills. All OVCA packages contain two Work Keys assessments:

- *Applied Mathematics* measures students' ability to analyze, set up, and solve math problems typically found in the workplace.
- *Locating Information* measures students' ability to use graphic documents to insert, extract, and apply information.

In addition, certain taxonomies will use the following Work Keys assessments:

- *Reading for Information* will be used by Business, Marketing, Home Economics, Health Education, and Cosmetology taxonomies.
- *Applied Technology* will be used by Trade and Industrial and Agricultural Education taxonomies.

Other optional Work Keys assessments, not included in the basic OVCA package, are *Teamwork*, *Listening*, and *Writing*.

Each Work Keys assessment is further broken down into four to five levels of achievement, with higher numbers indicating higher achievement in the assessed skill (descriptions of the levels for each Work Keys assessment are provided on pp. 39-45). For each academic skill, the Job Profiling process identifies the level required for successful entry into an occupational area.

Job Profiling—How It Works

VIML's Job Profiling process was initiated by mailing surveys to current workers in OCAP occupations all across Ohio. The survey's purpose: to have actual workers in specific occupations rate job tasks according to each task's frequency and criticality—that is, the amount of time spent performing each task relative to other tasks and the importance of each task to overall job performance.

To complete the survey, participants examined OCAP competencies for their occupation. Based on the survey's results, VIML staff produced a list of the most critical competencies in each occupation.

The next stage of Job Profiling was to convene committees of subject-matter experts to perform "leveling," which involved the following tasks:

- Examining the frequency and criticality competency lists for an occupation
- Reviewing the levels associated with each of the seven Work Keys academic skills: *Locating Information, Reading for Information, Applied Mathematics, Applied Technology, Listening, Writing,* and *Teamwork*
- Identifying the level of skill students must master relative to each Work Keys academic skill in order to successfully perform the occupational competencies

Finally, in 1995, the initial leveling of Work Keys academic skills for the occupational area covered by this OCAP was revalidated by the new employer panel convened to update the OCAP (see inside back cover).

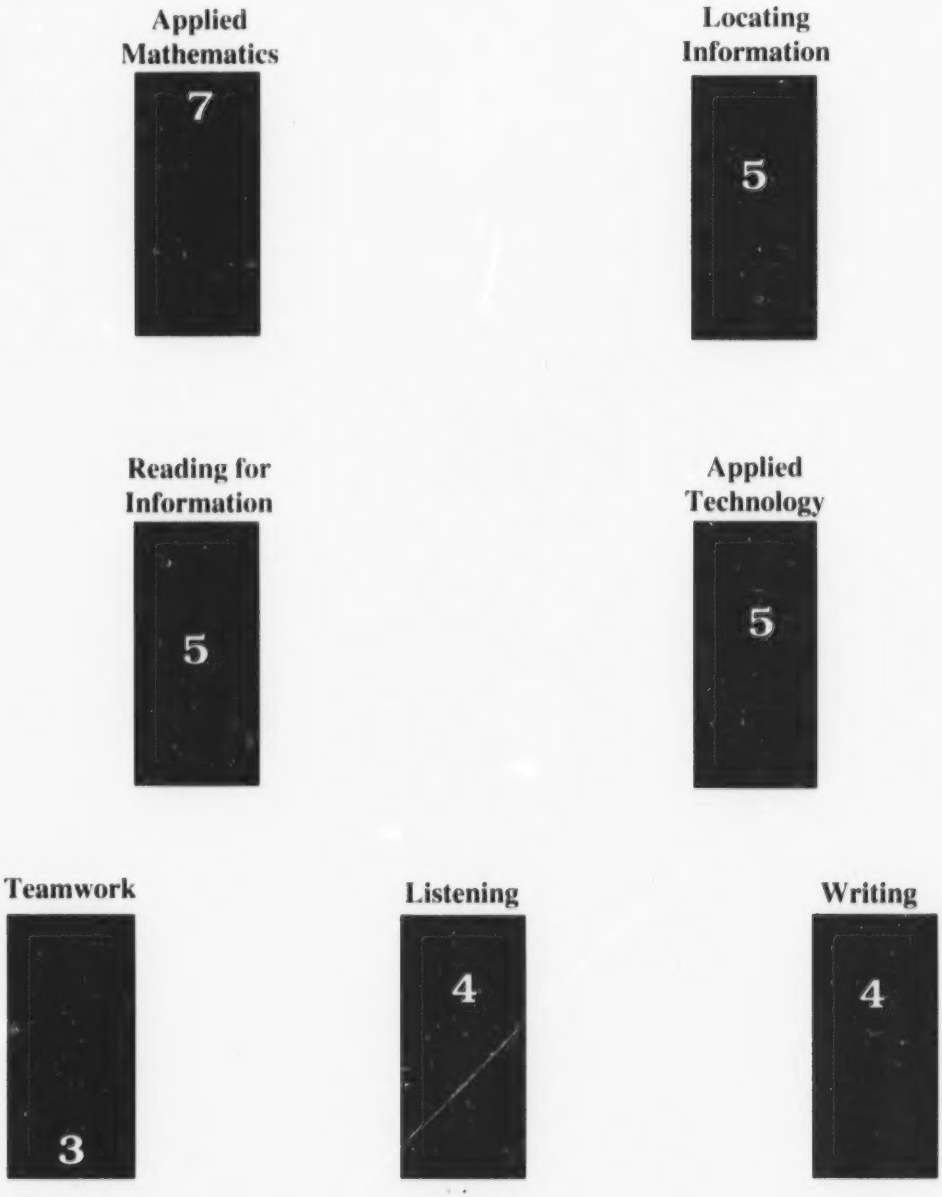
Example of Job Profiling

For every occupational area, there are shaded graphs to represent each of the seven Work Keys academic skills. Each graph shows the range of levels for that particular skill; the shading represents the academic skill level required by an entry-level worker in that occupation, as determined by the Job Profiling committee. For example:

Applied Mathematics

In the example shown, Applied Mathematics has a skill range of 3–7. The required skill level, determined by Job Profiling and shown by the highlighting, is 6.

Academic Job Profile: Precision Machining Technologies



NOTE: Definitions of each level in each of the seven academic skill areas are provided on the pages that follow.

Levels of Work Keys Defined

The skills needed to achieve each level for each of the seven Work Keys* academic skills are as follows.

Applied Mathematics

Applied Mathematics measures skill in applying mathematical reasoning to work-related problems. There are five levels of complexity, 3 through 7, with Level 3 being the least complex and Level 7 the most complex. The levels build on each other, each incorporating the skills at the preceding levels.

Level 3

- Perform basic mathematical operations (addition, subtraction, multiplication, and division) and conversions from one form to another, using whole numbers, fractions, decimals, or percentages.
- Translate simple verbal problems into mathematical equations.
- Directly apply logical information provided to solve problems, including those with measurements and dollars and cents.

Level 4

- Perform one or two mathematical operations (such as addition, subtraction, or multiplication) on several positive or negative numbers. (Division of negative numbers is not covered until Level 5.)
- Add commonly known fractions, decimals, or percentages (e.g., ½, .75, 25%) or add three fractions that share a common denominator.
- Calculate averages, simple ratios, proportions, and rates, using whole numbers and decimals.
- Reorder verbal information before performing calculations.
- Read simple charts or graphs to obtain information needed to solve a problem.

Level 5

- Look up and calculate single-step conversions within English or non-English measurement systems (e.g., converting ounces to pounds or centimeters to meters) or between measurement systems (e.g., converting centimeters to inches).
- Make calculations using mixed units (e.g., hours and minutes).
- Determine what information, calculations, and unit conversions are needed to find a solution.

Level 6

- Calculate using negative numbers, fractions, ratios, percentages, mixed numbers, and formulas.
- Identify and correct errors in calculations.
- Translate complex verbal problems into mathematical expressions, using considerable setup and multiple-step calculations or conversions.

Level 7

- Solve problems requiring multiple steps of logic and calculation.
- Solve problems involving more than one unknown, nonlinear functions (e.g., rate of change), and applications of basic statistical concepts (e.g., error of measurement).
- Locate errors in multiple-step calculations.
- Solve problems with unusual content or format, or with incomplete or implicit information.

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Locating Information

Locating Information measures skill in using information taken from workplace graphics such as diagrams, blueprints, floor plans, tables, forms, graphs, charts, and instrument gauges. There are four levels of complexity, 3 through 6, with Level 3 being the least complex and Level 6 the most complex. The levels build on each other, each incorporating the skills at the preceding levels.

Level 3

- Find one or two pieces of information in elementary workplace graphics, such as simple order forms, bar graphs, tables, flowcharts, and floor plans.
- Fill in one or two pieces of information that are missing from elementary workplace graphics.

Level 4

- Find several pieces of information in straightforward workplace graphics, such as basic order forms, line graphs, tables, instrument gauges, maps, flowcharts, and diagrams.
- Summarize and/or compare information and trends in a single straightforward graphic.
- Summarize and/or compare information and trends among more than one straightforward workplace graphic, such as a bar chart and a data table showing related information.

Level 5

- Summarize and/or compare information and trends in single complicated workplace graphics, such as detailed forms, tables, graphs, maps, instrument gauges, and diagrams.
- Summarize and/or compare information and trends among more than one complicated workplace graphic, such as a bar chart and a data table showing related information.

Level 6

- Make decisions, draw conclusions, and/or apply information to new situations using several related and complex workplace graphics that contain a great amount of information or have challenging presentations (e.g., very detailed graphs, charts, tables, forms, maps, blueprints, diagrams).

Reading for Information

Reading for Information measures skill in reading and understanding work-related reading materials. There are five levels of complexity, 3 through 7, with Level 3 being the least complex and Level 7 the most complex. Although Level 3 is the least complex, it still represents a level of reading skill well above "no skill at all." The levels build on each other, each incorporating the skills at the preceding levels.

Level 3

- Identify uncomplicated key concepts and simple details.
- Recognize the proper placement of a step in a sequence of events, or the proper time to perform a task.
- Identify the meaning of words that are defined within a passage.
- Identify the meaning of simple words that are not defined within a passage.
- Recognize the application of instructions from a passage to situations that are described in the passage.

Level 4

- Identify details that are more subtle than those in Level 3.
- Recognize the application of more complex instructions, some of which involve several steps, to described situations.
- Recognize cause-effect relationships.

Level 5

- Identify the paraphrased definition of jargon or technical terms that are defined in a passage and recognize the application of jargon or technical terms to stated situations.
- Recognize the definition of acronyms that are defined in a passage.
- Identify the appropriate definition of words with multiple meanings.
- Recognize the application of instructions from a passage to new situations that are similar to the situations described in the reading materials.
- Recognize the applications of more complex instructions to described situations, including conditionals and procedures with multiple steps.

Level 6

- Recognize the application of jargon or technical terms to new situations.
- Recognize the application of complex instructions to new situations.
- Recognize the less-common meaning of a word with multiple meanings from context.
- Generalize from a passage to situations not described in the passage.
- Identify implied details.
- Explain the rationale behind a procedure, policy, or communication.
- Generalize from a passage to a somewhat similar situation.

Level 7

- Recognize the definitions of difficult, uncommon jargon or technical terms from context.
- Generalize from a passage to situations neither described in nor completely similar to those in a passage.

Applied Technology

Applied Technology measures skill in solving problems of a technological nature, involving the basic principles of mechanics, electricity, fluid dynamics, and thermodynamics as they apply to machines and equipment found in the workplace. There are four levels of complexity, 3 through 6, with Level 3 being the least complex and Level 6 the most complex. Although Level 3 is the least complex, it still represents a level of applied technology skill well above "no skill at all." The levels build on each other, each incorporating the skills at the preceding levels.

Level 3

- Apply the elementary physical principles underlying the operation of uncomplicated systems or tools.
- Recognize and identify relevant aspects of simple problems that involve one uncomplicated system or tool.
- Select appropriate methods or materials needed to solve problems.

Level 4

- Recognize, identify, and order relevant aspects of one moderately complex system or more than one uncomplicated system.
- Evaluate alternative solutions to determine the most appropriate one for the situation presented.

Level 5

- Solve problems based on one complex system, or one or more uncomplicated tools or systems.
- Understand and apply moderately difficult principles of mechanics, electricity, thermodynamics, and fluid dynamics, in addition to understanding complex machines and systems.
- Recognize, identify, and order relevant aspects of a problem before reaching an appropriate solution.

Level 6

- Solve problems that do not contain all the information needed to solve them, and/or in which the information provided may be out of logical order.
- Solve problems that contain extraneous information.
- Solve problems involving one or more tools or systems having a wide range of complexity.
- Apply difficult physical principles.
- Understand and correctly interpret the interaction of several complex systems.

Listening

Listening measures skill in listening to and understanding work-related messages; receiving information from customers, coworkers, or suppliers; and then writing down the information to communicate it to someone else. Students demonstrate their ability to distinguish and communicate critical information and noncritical information. **Critical information** consists of those details that the recipient of the message must have in order to understand the message and act upon it (e.g., names, phone numbers, addresses, times). **Noncritical information** can improve a message by providing details that further explain the message or its tone, but the absence of this noncritical information does not interfere with the recipient's ability to understand and accurately act upon the message. Each *Listening* level describes the **content and quality** of messages students write to describe an audio message.

Level 0

- No meaningful information, or totally inaccurate information.

Level 1

- Minimal pertinent information; enough context to provide clues as to gist of situation or source of further information.

Level 2

- Some pertinent information; may have incorrect critical information, but sketch of the situation is correct.

Level 3

- All the critical information that is present is correct; may be missing a few pieces of critical information.

Level 4

- All critical information is given and is correct; may be missing subtle details or tone; may have incorrect noncritical information that does not interfere with central meaning.

Level 5

- All critical information is present and correct; response conveys insight into situation through tone and/or subtle details.

Writing

Writing measures skill at writing work-related messages: receiving information from customers, co-workers, or suppliers; and then writing down the information to communicate it to someone else. Each *Writing* level rates the **writing mechanics** (such as sentence structure and grammar) **and writing style** of messages students write to describe an audio message.

Level 0

- An attempt is made at the message, but the message is completely garbled with no recognizable sentence structure.

Level 1

- Message conveyed inadequately; overall lack of proper sentence structure.

Level 2

- Message conveyed inadequately; weak sentence structure; large number of mechanical errors.

Level 3

- Message conveyed clearly; most sentences complete; some mechanical errors.

Level 4

- Message conveyed clearly; all sentences are complete; may have a few minor mechanical errors; may have a choppy style.

Level 5

- Message conveyed clearly; good sentence structure; no mechanical errors; highly appropriate for business setting and situation; smooth, logical style.

Teamwork

Teamwork measures skill in choosing behaviors and/or actions that simultaneously support team interrelationships and lead toward the accomplishment of work tasks. There are four levels of complexity, 3 through 6, with Level 3 being the least complex and Level 6 the most complex. Although Level 3 is the least complex, it still represents a level of teamwork skill well above "no skill at all." The levels build on each other, each incorporating the skills at the preceding levels.

Level 3

- Identify team goals and ways to work with other team members to accomplish those goals.
- Choose actions that support the ideas of other team members to accomplish team goals.
- Recognize that a team is having problems finishing a task and identify the cause of those problems.

Level 4

- Identify the organization of tasks and the time schedule that would help accomplish team goals efficiently and effectively.
- Select approaches that accept direction from other team members in order to accomplish tasks and to build and keep up good team relations.
- Identify behaviors that show appreciation for the personal and professional qualities of other team members and respect for their diversity.

Level 5

- Identify courses of action that give direction to other team members effectively.
- Choose approaches that encourage and support the efforts of other team members to further team relationships and/or task accomplishment.
- Consider the possible effects of alternative behaviors on both team relationships and team accomplishments and select the one that would best help the team meet its goals.

Level 6

- Identify the focus of team activity and select a new focus if that would help the team meet its goals more effectively.
- Select approaches that show the willingness to give and take direction as needed to further team goals (e.g., recognize the organization of team members' tasks that would best serve the larger goals of the team).
- Choose approaches that encourage a team to act as a unit and reach agreement when discussing specific issues.
- Identify actions that would help manage differences of opinion among team members, moving the team toward its goals while valuing and supporting individual diversity.

Notes

Academic Competencies

Total List of Academic Competencies

Three products of the Ohio Department of Education, Division of Curriculum, Instruction, and Professional Development, describe the academic skills that should be possessed by each student at the end of each grade level:

- *Model Competency-Based Language Arts Program*
- *Model Competency-Based Mathematics Program*
- *Model Competency-Based Science Program*

The following lists were derived from the academic competencies delineated for Grades 9-12 in these documents. Although the competencies are listed separately by grade level in the original documents, the levels were combined—and in some cases refined—for OCAP purposes, any overlap was eliminated, and a numbering system was imposed for ease of reference.

During the course of the OCAP workshops, each of the representatives from business, industry, labor, and community-based organizations was given a copy of these lists of academic competencies and instructed to circle the competencies that an entry-level employee should possess. The results from each panel were tallied to identify those required academic competencies most crucial to entry level in each specific occupational area. The results for this OCAP are presented on pp. 63-67.

Unit: Communications Skills

Subunit: Reading—Structure

Competencies:

RS1 Exhibit knowledge of language structure
RS2 Recognize that there may be more than one interpretation of reading selections
RS3 Recognize various literary devices (e.g., metaphor, simile, personification, hyperbole, pun, alliteration)
RS4 Recognize and discuss literary elements (e.g., plot, dialogue, theme, setting, characterization)
RS5 Develop and use an increasingly sophisticated vocabulary gained through context
RS6 Apply knowledge of language structure to reading
RS7 Explain why there may be more than one interpretation of reading selections
RS8 Recognize effect of literary devices on meaning
RS9 Analyze author's use of literary elements
RS10 Recognize relationship of structure to meaning
RS11 Describe various interpretations and levels of meaning in reading selections (e.g., symbolism, nuance)
RS12 Characterize author's use of literary devices
RS13 Characterize use of literary techniques (e.g., irony, satire, allegory, onomatopoeia)
RS14 Critique a variety of literature with regard to plot, dialogue, theme, setting, and characterization
RS15 Apply an expanding vocabulary gained through reading
RS16 Explain various interpretations and levels of meaning in reading selections (e.g., symbolism, nuance)
RS17 Analyze use of literary devices (e.g., extended metaphor, simile, personification, hyperbole, pun, alliteration)
RS18 Understand use of literary techniques (e.g., irony, satire, allegory, onomatopoeia)
RS19 Analyze and synthesize pieces of literature with regard to plot, dialogue, theme, setting, and characterization

Subunit: Reading—Meaning Construction

Competencies:

- RM1 Demonstrate ability to recognize appropriate pre-reading strategies
- RM2 Describe effectiveness of a reading selection
- RM3 Read to clarify personal thinking and knowledge
- RM4 Support interpretation of text by locating and citing specific information
- RM5 Develop personal response to a variety of literary works
- RM6 Recognize diverse literary interpretations
- RM7 Engage in self-selected reading activities
- RM8 Confirm and extend meaning in reading by researching new concepts and facts
- RM9 Self-monitor and apply corrective strategies when communication has been interrupted or lost
- RM10 Use features of literary genres to extend meaning
- RM11 Assess effectiveness of a selection read
- RM12 Use reading as a possible problem-solving strategy to clarify personal thinking and knowledge
- RM13 Use knowledge of semantic elements (e.g., figurative language, denotation, connotation, dialect) to clarify meaning when reading
- RM14 Predict, recognize, interpret, and analyze themes based on familiarity with author's work
- RM15 Compare and contrast literary genres
- RM16 Assess validity and quality of selection read (e.g., predict, summarize, analyze, infer)
- RM17 Clarify meaning when reading, using knowledge of literary devices, stylistic diction, and other semantic elements
- RM18 Compare personal reaction to critical assessment of a literary selection
- RM19 Assess validity of diverse literary interpretations
- RM20 Use reference books to find, evaluate, and synthesize information
- RM21 Identify tone of a literary work (e.g., ironic, serious, conversational, humorous)
- RM22 Critique validity of diverse literary interpretations
- RM23 Integrate personal reaction to and critical assessment of a literary selection

Subunit: Reading—Application

Competencies:

- RA1 Select and read material for personal enjoyment and information
- RA2 Read a variety of complete, unabridged works (e.g., self-selected or assigned stories, essays, nonfiction, plays, novels, poetry)
- RA3 Employ various reading strategies (e.g., scanning, skimming, reviewing, questioning, testing, retaining) according to purpose
- RA4 Participate in selection of books, materials, and topics for literature study groups
- RA5 Develop and apply knowledge of the interrelationship of concepts (e.g., construction of webs, graphs, timelines)
- RA6 Read selections from a variety of styles and formats, recognizing that style and format influence meaning
- RA7 Extend value of reading, writing, speaking, viewing, and listening by pursuing, through reading, new concepts and interests developed as a result of these activities
- RA8 Read extensively from the works of a particular author, and explain elements of author's style

Subunit: Reading—Multidisciplinary

Competencies:

- RM1 Connect themes and ideas across disciplines through literature
- RM2 Read to facilitate learning across curriculum
- RM3 Read to develop awareness of human rights and freedom
- RM4 Participate actively in a community of learners

RM5 Recognize and explain interaction between literature and various cultural domains (e.g., social, technological, political, economic)
RM6 Explore and analyze a variety of cultural elements, attitudes, beliefs, and value structures by reading and experiencing our diverse literary tradition, including works by men and women of many racial, ethnic, and cultural groups
RM7 Value thinking and language of others
RM8 Relate literature to historical period about which or in which it was written
RM9 Read to facilitate content learning

Subunit: Writing—Structure

Competencies:

WS1 Develop and expand a repertoire of organizational strategies (e.g., narration, comparison/contrast, and description) through practice and discussion
WS2 Clarify word choice according to audience, topic, and purpose
WS3 Locate and correct errors in usage, spelling, and mechanics (e.g., subject-verb agreement, parallel construction, pronoun reference, punctuation, capitalization, sentence structure) using a variety of resources
WS4 Recognize information gained from primary and secondary sources
WS5 Develop writing that contains ordered, related, well-developed paragraphs with sentences of varied lengths and patterns
WS6 Use information from a variety of sources to develop an integrated piece of writing
WS7 Evaluate and revise writing to focus on such things as audience, tone, and purpose
WS8 Recognize differences between documentation and reference list styles
WS9 Develop extended pieces of writing that contain ordered, related, well-developed paragraphs with sentences of varied lengths and patterns
WS10 Select from a repertoire of organization strategies a pattern appropriate to a topic (e.g., narration, example, detail, comparison/contrast, classification)
WS11 Synthesize information from a variety of sources to construct meaning
WS12 Refine word choice and tone according to audience, situation, and purpose
WS13 Appropriately cite information gained from primary and secondary sources
WS14 Use style manuals or software to prepare documentation and reference lists
WS15 Develop effectively organized pieces of expository writing containing strong voice, clear thesis, and well-developed ideas
WS16 Identify organization patterns appropriate to writing topic
WS17 Respond to others' suggested revisions to a writing piece

Subunit: Writing—Meaning Construction

Competencies:

WM1 Demonstrate knowledge of the recursive nature of the writing process by applying it appropriately to various topics, situations, and audiences (e.g., making connections between prior knowledge and new information, consulting other sources)
WM2 Develop criteria for writing evaluation using scoring guides (e.g., rubric/holistic scale, primary trait scoring) and peer/teacher assistance to clarify meaning
WM3 Respond to others' suggested revisions to a piece of writing (e.g., self-question, re-read, revise)
WM4 Use word processing, graphics, and publishing as aids for constructing meaning in writing
WM5 Engage in self-initiated writing activities
WM6 Incorporate personal criteria with generally accepted standards for writing evaluation
WM7 Evaluate, analyze, and synthesize information for writing
WM8 Evaluate own writing using personal and established scoring criteria
WM9 Assess personal/peer revisions to a writing piece
WM10 Recognize and refine personal writing styles

Subunit: Writing—Application

Competencies:

- WA1 Apply appropriate writing techniques (e.g., prewriting, drafting, revising, editing, presenting) suitable for varied writing tasks
- WA2 Use sentence-combining techniques to improve syntactic fluency and maturity
- WA3 Write in response to prompted and self-selected topics in practical, persuasive, descriptive, narrative, and expository domains
- WA4 Develop personal voice in writing
- WA5 Consider audience and purpose for writing
- WA6 Develop criteria for selection and potential development of topic
- WA7 Write in a journal or learning log to clarify personal thinking and knowledge
- WA8 Apply an expanding vocabulary gained through writing
- WA9 Make judicious use of reference sources (e.g., dictionary, thesaurus, online database, encyclopedia)
- WA10 Demonstrate an appreciation for aesthetically pleasing language through word choice and style
- WA11 Apply revising and editing strategies needed for writing task
- WA12 Vary sentence lengths and patterns
- WA13 Refine personal voice in writing
- WA14 Vary styles and formats for intended purpose and audience
- WA15 Apply criteria for selection and development of topic
- WA16 Participate in peer review of writing in progress
- WA17 Use transitions between sentences, ideas, and paragraphs in writing
- WA18 Revise and edit papers extensively in preparation for presentation/publication
- WA19 Develop a variety of genres (e.g, fantasy, science fiction, short stories, poetry)
- WA20 Focus writing and tone on such elements as audience, situation, and purpose
- WA21 Develop topic fully and appropriately
- WA22 Use writing process to clarify personal thinking and knowledge
- WA23 Apply appropriate recursive writing process as suggested by writing task and writer's process
- WA24 Develop an extended piece of writing (e.g., story, narrative poem, autobiography, novel, research paper)
- WA25 Revise writing and tone to assure focus on such elements as audience, situation, and purpose
- WA26 Use writing process to write reflectively

Subunit: Writing—Multidisciplinary

Competencies:

- WM1 Use writing process for learning across curriculum
- WM2 Use writing process to demonstrate knowledge of need for human rights and freedom
- WM3 Value and apply collaborative skills in the writing process
- WM4 Write in response to reading, speaking, viewing, and listening
- WM5 Use multidisciplinary resources in writing projects
- WM6 Use writing process to facilitate learning across curriculum
- WM7 Recognize value of and engage in collaboration in the writing process
- WM8 Use communication processes to develop a published writing piece in collaboration with others
- WM9 Record experiences and observations related to content learning
- WM10 Apply collaborative skills in the writing process
- WM11 Write collaboratively with peers
- WM12 Use cross-disciplinary resources in writing projects

Subunit: Listening/Visual Literacy—Structure

Competencies:

- LS1 Listen to and view a wide variety of genres (e.g, mystery, drama, poetry)
- LS2 Become aware of an author's style through listening to and viewing a variety of works

LS3 Recognize correct and appropriate grammar, diction, and syntax
LS4 Expand vocabulary through listening to and viewing varied media (e.g., recordings, films, music, news broadcasts)
LS5 Recognize beauty of language
LS6 Enhance recognition of an author's style through listening to and viewing a variety of works
LS7 Recognize use and misuse of language in media
LS8 Refine knowledge of style through listening to and viewing multiple works by the same author
LS9 Expand and refine grammar, diction, and syntax through listening
LS10 Compare authors' styles through viewing and listening to their works
LS11 Expand knowledge of complex grammar, diction, and syntax issues

Subunit: Listening/Visual Literacy—Meaning Construction

Competencies:

LM1 Develop critical thinking skills necessary to evaluate media and assess oral presentations
LM2 Compare new oral texts to past experiences and knowledge in order to enhance comprehension
LM3 Recognize how rhythmic patterns, silence, and cadences enhance quality of speech and literature
LM4 Focus listening and viewing on themes and/or plots
LM5 Gather information from listening and viewing experiences to enhance research
LM6 Use critical thinking skills to evaluate media and oral presentations
LM7 Use prior knowledge and experiences to facilitate comprehension of new oral texts
LM8 Identify rhythmic and time patterns in speech and literature
LM9 Identify and analyze themes and/or plots when listening and viewing
LM10 Use information gathered from listening and viewing experiences to expand research
LM11 Enhance use of critical thinking skills to evaluate media and oral presentations
LM12 Consider prior knowledge and experiences when attempting to understand the meaning of new texts
LM13 Appreciate rhythmic and time patterns of speech and literature
LM14 Select viewing and listening materials to support written text
LM15 Evaluate media and oral presentations analytically and critically
LM16 Organize prior knowledge and experiences to comprehend new texts
LM17 Organize and use viewing and listening materials to support written text

Subunit: Listening/Visual Literacy—Application

Competencies:

LA1 Listen attentively during oral reading
LA2 Use media as stimuli for learning and thinking
LA3 Develop knowledge of structure through art, music, and literature
LA4 Use electronic media to enhance and highlight language learning
LA5 Listen and view for entertainment and enjoyment
LA6 Use technology and other media (e.g., videos, posters, maps, graphs, t-shirts) as means of expressing ideas

Subunit: Listening/Visual Literacy—Multidisciplinary

Competencies:

LM1 Facilitate learning across curriculum through critical listening and viewing
LM2 Engage in individual, small-group, and whole-group listening and viewing activities
LM3 Develop language arts (e.g., viewing, listening) projects collaboratively
LM4 Investigate language and cultural differences through listening and viewing activities
LM5 Participate in a community of learners through productive listening

Subunit: Oral Communication—Structure

Competencies:

- OS1 Refine oral communication skills (e.g., voice modulation, eye contact, body language)
- OS2 Demonstrate knowledge of grammar, usage, and syntax when presenting
- OS3 Select topics and vocabulary suitable to audience
- OS4 Organize notes and ideas for speaking (e.g., cause-effect, chronological, exemplification)
- OS5 Use language imaginatively (e.g., word games, puns, limericks)
- OS6 Modulate voice to enhance meaning when interpreting literature orally
- OS7 Organize notes and ideas for formal, semiformal, and informal presentations of information
- OS8 Refine speaking techniques for formal, semiformal, and informal settings
- OS9 Develop repertoire of organizational strategies for presenting information orally
- OS10 Expand vocabulary to fit topic
- OS11 Select topics suitable to audience, situation, and purpose
- OS12 Select appropriate strategies when organizing notes and ideas for speaking

Subunit: Oral Communications—Meaning Construction

Competencies:

- OM1 Make connections between prior knowledge and new information for oral presentations
- OM2 Participate in informal speaking activities (e.g., offering opinions, supporting statements, questions, clarification, entertainment)
- OM3 Use interviewing techniques to gather information
- OM4 Communicate orally to entertain and to inform
- OM5 Participate in group communication activities (e.g., debates, panel discussions, negotiations, book-sharing, roundtables, cooperative/collaborative groups)
- OM6 Take and organize notes when preparing speech/presentation
- OM7 Interpret texts orally to illustrate meaning
- OM8 Respond to needs of various audiences
- OM9 Gather and assess information for speaking
- OM10 Communicate orally to inform and persuade
- OM11 Prepare and deliver formal speech/presentation
- OM12 Participate in a variety of oral interpretations
- OM13 Assess needs of audience, and adjust language and presentation according to their knowledge
- OM14 Analyze and synthesize information for speaking
- OM15 Describe effectiveness of a literary selection
- OM16 Describe topic or idea in order to clarify personal/audience thinking
- OM17 Analyze and synthesize information gathered from a variety of sources (e.g., interviews, hypermedia, reference works) for speaking
- OM18 Describe validity and/or quality of a literary selection and justify selection
- OM19 Interpret orally a variety of literature
- OM20 Describe topic or idea to clarify meaning for others

Subunit: Oral Communication—Application

Competencies:

- OA1 Become proficient at using interviewing techniques
- OA2 Give an oral interpretation for a specific audience
- OA3 Develop and apply oral communication skills for cooperative/collaborative learning
- OA4 Use oral communication for a variety of purposes and audiences (e.g., negotiations, book reviews, rationales)
- OA5 Develop and apply decision-making strategies
- OA6 Practice interviewing techniques
- OA7 Apply interviewing techniques to purposeful interviews
- OA8 Focus oral interpretation on a specific audience

Subunit: Oral Communications—Multidisciplinary

Competencies:

- OM1 Value thinking and language of others
- OM2 Develop oral projects collaboratively
- OM3 Be involved in individual, small-group, and whole-group language activities
- OM4 Participate actively in a community of learners
- OM5 Investigate language and cultural differences through oral language activities

Unit: Mathematics Skills

Subunit: Numbers and Number Relations

Competencies:

- NR1 Compare, order, and determine equivalence of real numbers
- NR2 Estimate answers, compute, and solve problems involving real numbers
- NR3 Compare and contrast real number system, rational number system, and whole number system
- NR4 Extend knowledge to complex number system, and develop facility with its operation

Subunit: Measurement

Competencies:

- M1 Estimate and use measurements
- M2 Understand the need for measurement and the probability that any measurement is accurate to some designated specification
- M3 Understand and apply measurements related to power and work
- M4 Understand and apply measurement concepts of distance-rate-time problems and acceleration problems with real-world experiments
- M5 Use real experiments to investigate elasticity, heat, sound, electricity, magnetism, light, acceleration, velocity, energy, and gravity
- M6 Use real-world problem situations involving mass and weight
- M7 Use real-world problem situations involving simple harmonic motion
- M8 Establish ratios with and without common units
- M9 Construct and interpret maps, tables, charts, and graphs as they relate to real-world mathematics
- M10 Understand and solve rate-change problems
- M11 Understand and solve right triangle relationships as they relate to measurement—specifically those that deal with the Pythagorean theorem
- M12 Graph and interpret ordered pairs
- M13 Compute total sales from a variety of items
- M14 Comprehend and compute rates of growth or decay
- M15 Comprehend, compute, and interpret real problems involving annuities
- M16 Develop an ability to identify real problems and provide possible solutions
- M17 Express and apply different types of measurement scales
- M18 Determine area and volume

NOTE: The math subunit on problem solving was not included on this list since it should be a continuing thread throughout all instruction rather than a separate set of competencies.

Subunit: Estimation and Mental Computation

Competencies:

- E1 Use estimation to eliminate choices in multiple-choice tests
- E2 Use estimation to determine reasonableness of problem situations in a wide variety of applications
- E3 Estimate shape of graphs of various functions and algebraic expressions
- E4 Use mental computation when computer and calculator are inappropriate

Subunit: Data Analysis and Probability

Competencies:

- D1 Organize data into tables, charts, and graphs
- D2 Understand and apply measures of central tendency, variability, and correlation
- D3 Use curve fitting to predict from data
- D4 Use experimental or theoretical probability, as appropriate, to represent and solve problems involving uncertainty
- D5 Use computer simulations and random number generators to estimate probabilities
- D6 Test hypotheses using appropriate statistics
- D7 Read, interpret, and use tables, charts, and graphs to identify patterns, note trends, draw conclusions, and make predictions
- D8 Identify probabilities of events involving unbiased objects
- D9 Use sampling and recognize its role in statistical claims
- D10 Design a statistical experiment to study problem, conduct experiment, and interpret and communicate outcomes
- D11 Describe normal curve in general terms, and use its properties
- D12 Create and interpret discrete probability distributions
- D13 Understand concept of random variable
- D14 Apply concept of random variable to generate and interpret probability distributions, including binomial, uniform, normal, and chi square

Subunit: Algebra

Competencies:

- A1 Describe problem situations by using and relating numerical, symbolic, and graphical representations
- A2 Use language and notation of functions in symbolic and graphing settings
- A3 Recognize, relate, and use the equivalent ideas of zeros of a function, roots of an equation, and solution of an equation in terms of graphical and symbolic representations
- A4 Describe and use logic of equivalence in working with equations, inequalities, and functions
- A5 Develop graphical techniques of solution for problem situations involving functions
- A6 Explore and describe characterizing features of functions
- A7 Make arguments and proofs in algebraic settings
- A8 Factor difference of two squares
- A9 Determine slope, midpoint, and distance
- A10 Explore and combine rational functions
- A11 Explore factoring techniques
- A12 Solve quadratic equations by factoring and formula
- A13 Set up and solve linear equations
- A14 Solve systems of linear equations with two variables
- A15 Describe geometric situations and phenomena using variables, equations, and functions
- A16 Describe measures of central tendency, mean, median, mode, and variance algebraically and graphically
- A17 Represent inequalities on the number line and in the coordinate plane
- A18 Use coordinate arguments in making geometric proofs

A19 Symbolize transformations of figures and graphs
A20 Explore geometric basis for functions of trigonometry
A21 Graph linear functions
A22 Develop and use vectors to represent direction and magnitude, including operations
A23 Use polar and parametric equations to describe, graph, and solve problem situations
A24 Represent sequences and series as functions both algebraically and graphically
A25 Explore recursive functions and procedures using spreadsheets, other computer utilities, and notions appropriate to these problem situations
A26 Describe and solve algebraic situations with matrices
A27 Describe and use inverse relationship between functions, including exponential and logarithmic
A28 Analyze and describe errors (and their sources) that can be made when using computers and calculators to solve problems
A29 Decide whether problem situation is best solved using computer, calculator, paper and pencil, or mental arithmetic/estimation techniques
A30 Explore relationships between complex numbers and vectors
A31 Make arguments concerning limits, convergence and divergence in contexts involving sequences, series, and other types of functions
A32 Represent transformations in the plane with matrices
A33 Contrast and compare algebras of rational, real, and complex numbers with characteristics of a matrix algebra system
A34 Construct polynomial approximations of a function over specified intervals of convergence
A35 Examine complex numbers as zeros of functions
A36 Translate verbal statements into symbolic language
A37 Simplify algebraic expressions
A38 Use laws and exponents (including scientific notation)
A39 Expand and extend idea of vectors and linear algebra to higher dimensional situations
A40 Use the idea of independent basis elements for a vector space and associated fundamental concepts of finite dimensional linear algebra
A41 Develop and communicate arguments about limit situations
A42 Use matrices to describe and apply transformations
A43 Develop and use polar and parametric equations to represent problem situations
A44 Explore proofs by mathematical induction

Subunit: Geometry

Competencies:

G1 Create and interpret drawings of three-dimensional objects
G2 Represent problem situations with geometric models and apply properties of figures
G3 Apply Pythagorean theorem
G4 Demonstrate knowledge of angles and parallel and perpendicular lines
G5 Explore inductive and deductive reasoning through applications to various subject areas
G6 Translate between synthetic and coordinate representations
G7 Identify congruent and similar figures using transformation with computer programs
G8 Deduce properties of figures using transformations and coordinates
G9 Use deductive reasoning
G10 Explore compass and straightedge constructions in context of geometric theorems
G11 Demonstrate knowledge of and ability to use proof
G12 Use variety of proof techniques (e.g., synthetic, transformational, and coordinate)
G13 Use variety of proof formats, including T-proof (i.e., two-column) and paragraph proof
G14 Explore different proof strategies
G15 Investigate different proofs of theorems
G16 Develop knowledge of an axiomatic system
G17 Apply transformations and coordinates in problem solving
G18 Represent problem situations with geometric models, and apply properties of figures

G19 Deduce properties of figures using vectors
G20 Analyze properties of Euclidean transformations, and relate translations to vectors
G21 Apply vectors in problem solving
G22 Develop further knowledge of axiomatic systems by investigating and comparing various geometries

Subunit: Patterns, Relations, and Functions

Competencies:

P1 Model real-world phenomena with polynomial and exponential functions
P2 Explore relationship between zeros and intercepts of functions
P3 Translate among tables, algebraic expressions, and graphs of functions
P4 Use graphing calculator or computer to generate graph of a function
P5 Explore relationship between a linear function and its inverse
P6 Describe and use characteristics of polynomial functions in problem-solving situations
P7 Explore conic sections, and graph using graphing calculator or computer
P8 Apply trigonometric functions to problem situations involving triangles
P9 Discover general relationships between algebraic description of conic, kind of conic, and special properties of that conic
P10 Explore periodic real-world phenomena using sine and cosine functions
P11 Analyze effects of parameter changes on graphs
P12 Use graphing calculator or computer to graph functions
P13 Develop a knowledge of rational and transcendental functions
P14 Understand connections between trigonometric and circular functions
P15 Use circular functions to model periodic real-world functions
P16 Solve trigonometric equations, and verify trigonometric identities
P17 Understand connections between trigonometric functions and polar coordinates, exponential functions , logarithmic functions, complex numbers, and series
P18 Model real-world phenomena with a variety of functions
P19 Graph using polar coordinates
P20 Explore graphs in three dimensions
P21 Explore functions of several variables
P22 Explore recursive functions using spreadsheets and/or programming languages

Unit: Science Skills

Subunit: Scientific Inquiry

Competencies:

Q1 Check the appropriateness and accuracy of measures and computations using various strategies (e.g., estimations, unit analysis, determination of significant figures)
Q2 Use ratios, proportions, and probabilities in appropriate problem situations
Q3 Translate information from and represent information in various forms with equal ease (e.g., tables, charts, graphs, diagrams, geometric figures)
Q4 Use existing algebraic formulas and create new ones in appropriate problem-solving situations
Q5 Estimate and justify probabilities of outcomes of familiar situations based on experimentation and other strategies
Q6 Invent apparatus and mechanical tools needed to perform unique tasks in various situations
Q7 Identify, compare, and contrast different modes of inquiry, habits of mind, and attitudes and dispositions
Q8 Design investigations that are safe and ethical (i.e., obtain consent and inform others of potential outcomes, risks, and benefits; and show evidence of concern for the health and safety of humans and non-human species)

Q9 Make and read scale drawings, maps, models, and other representations to aid planning and understanding
Q10 Seek elaboration and justification of data and ideas, and reflect on alternative interpretations of the information
Q11 Use appropriate units for counts and measures
Q12 Create and use databases (electronic and other) to collect, organize, and verify data and observations
Q13 Design and conduct investigations with multiple variables
Q14 Communicate the results of investigations clearly in a variety of situations
Q15 Examine relationships in nature, offer alternative explanations for the observations, and collect evidence that can be used to help judge among explanations
Q16 Trace the development (e.g., history, controversy, and ramifications) of various theories, focusing on supporting evidence and modification with new evidence
Q17 Select, invent, and use tools, including analog and digital instruments, to make and record direct measurements
Q18 Observe and document events and characteristics of complex systems
Q19 Explain the influence of perspective (e.g., spatial, temporal, and social) on observation and subsequent interpretations
Q20 Create multiple representations of the same data using a variety of symbols, descriptive languages, mathematical concepts, and graphic techniques
Q21 Generate testable hypotheses for observations of complex systems and interactions
Q22 Document potentially hazardous conditions and associated risks in selected homes and public areas
Q23 Participate in public debates, relying on documented and verified data to construct and represent a position on scientific issues
Q24 Construct and test models of physical, biological, social, and geological systems
Q25 Read, verify, debate, and, where necessary, refute research published in popular or technical journals of science (e.g., *Discover, Omni, Popular Mechanics*)
Q26 Explore discrepant events and develop and test explanations of what was observed
Q27 Conduct theory-based research using surveys, observational instruments, and other methods
Q28 Modify personal opinions, interpretations, explanations, and conclusions based on new information
Q29 Analyze error and develop explanations in various domains
Q30 Formulate taxonomic schemes based upon multivariate models that help to explain similarities and differences in form, distribution, behavior, survival, and origin of objects and organisms
Q31 Demonstrate various logical connections between related concepts (e.g., entropy, conservation of energy)
Q32 Account for discrepancies between theories and observations
Q33 Analyze the changes within a system when inputs, outputs, and interactions are altered
Q34 Create, standardize, and document procedures
Q35 Determine the sources of significant disparities between the predicted and recorded results, and change research procedures to minimize disparities
Q36 Research, locate, and propose applications for abstract patterns (e.g., fractals, Fibonacci sequences, string theory, orbitals)
Q37 Recognize and utilize classification systems for particles, elements, compounds, phenomena, organisms, and others for exploring and predicting properties and behaviors
Q38 Suggest and defend alternative experimental designs and data explanations (e.g., sampling, controls, safeguards)
Q39 Recognize and communicate differences between questions that can be investigated in a scientific way and those that rely on other ways of knowing
Q40 Draw conclusions based on the relationships among data analysis, experimental design, and possible models and theories
Q41 Suggest new questions as a result of reflection on and discussions about own scientific investigations
Q42 Investigate, assess, and comment on strengths and weakness of the descriptive and predictive powers of science
Q43 Create new information from representations of data in a variety of forms (e.g., symbols, descriptive languages, graphic formats) utilizing a variety of techniques (e.g., interpolations, extrapolations, linear regressions, central tendencies, correlations)

Subunit: Scientific Knowledge

Competencies:

- K1 Investigate various types of dynamic equilibrium (e.g., biological, geological, mechanical, chemical)
- K2 Investigate the relationship between the rates of energy exchange and the relative energy level of components within systems (e.g., trophic levels of ecosystems, osmosis, rate of heating and cooling, storms)
- K3 Investigate patterns in the natural world (e.g., heredity, crystalline structures, population and resource distributions, diffraction, dispersion, polarization)
- K4 Investigate models and theories that help to explain the interactions of components in systems (e.g., conservation of mass, energy, and momentum; foodwebs; natural selection; entropy; plate tectonics; chaos; relativity; social-psychology)
- K5 Investigate degrees of kinship among organisms and groups of organisms
- K6 Investigate the limits of the definition of life, and investigate organisms and physical systems that exist at or near these limits (e.g. viruses, quarks, black holes)
- K7 Investigate estimates and measurements of a wide range of distances and rates of change
- K8 Investigate the historical development of theories of change over time (e.g., natural selection, continental drift, the big bang, geologic change)
- K9 Investigate physical and chemical changes in living and nonliving systems (e.g., photosynthesis, weathering processes, glaciation, thermal effects of materials, energy cells)
- K10 Investigate simulations of nuclear change (e.g., radioactivity, half life, carbon dating)
- K11 Investigate conservation principles associated with physical, chemical, and nuclear changes
- K12 Formulate descriptions of the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects
- K13 Formulate models and hypotheses for patterns in the natural world (e.g., earth structures, transportation systems, migrations, communications, constellations)
- K14 Formulate explanations for the influences of objects and organisms on each other over time
- K15 Formulate and interpret explanations for change phenomena (e.g., mass extinctions, stellar evolution, punctuated equilibrium, molecular synthesis)
- K16 Formulate and interpret explanations for the magnitudes of diversity at different periods of geologic time (e.g., mutation, global cataclysms, continental drift, competition, mass extinctions)
- K17 Formulate interpretations of the structure, function, and diversity in a variety of organisms and physical systems (e.g., DNA and RNA variants, nucleons, interaction particles)
- K18 Formulate understandings of geologic time (e.g., millennia, periods, epochs)
- K19 Formulate an understanding of the historical development of the model of the universe (e.g., Aristotle, Ptolemy, Copernicus, Brahe, Kepler, Galileo, Newton, Einstein)
- K20 Formulate explanations and representations of the production, transmission, and conservation of energy in biological and physical systems (e.g., weather, volcanism, earthquakes, electricity, magnetism, cellular respiration)
- K21 Formulate models and hypotheses about patterns in the natural world (e.g., social behavior, molecular structure, energy transformation, entropy, randomness, aging, chaos, hormonal cycles)
- K22 Formulate interpretations of the relationship between energy exchange and the interfaces between components within systems
- K23a Formulate estimations for the range of energies within and between various phenomena (e.g., thermal, electromagnetic, thermonuclear, chemical, electrical)
- K23b Formulate explanations for the historical development of descriptions of motions interactions and transformations of matter and energy (e.g., classical Newtonian mechanics, special and general relativity, chaos)
- K24 Formulate models that can be used to describe fundamental molecular interactions in living and non-living systems (e.g., cell membranes, semiconductors).
- K25 Formulate an understanding of the degree of relationship among organisms and objects based on molecular structure (e.g., proteins, nucleic acids)
- K26 Formulate hypotheses and models that may account for observable events (e.g., electricity and magnetism, gravitation, atoms, bonding, chemical reactions, quantum effects, energy flow on biological systems, predator-prey relationships)

K27 Formulate models and hypotheses about change over time (e.g., natural selection, speciation, punctuated equilibrium, phyleytic gradualism, stellar evolution, plate tectonics, radioactive decay, quantum mechanical theory)
K28 Formulate lists of limitations, and propose refinements of standard classification systems (e.g., periodic table, IUPAC, Linnean, standard model)
K29 Formulate specific cases of limitations and possible exceptions of theories and principles regarding the interactions of moving objects and organisms (e.g., fluid flow in vessels, motion near the speed of light, Heisenberg uncertainty principle, meteorological prediction, local variation and diversity, earthquake prediction, energy transport in cellular respiration)
K30 Formulate plans and contingencies that can be used to accommodate for changes to and stresses on systems (e.g., wildlife and habitat management, corrosion prevention, noise abatement, structure design)
K31 Formulate models of molecular, atomic, ionic, and subatomic structures and the physical and biological implications of these structures (e.g., genes, nucleons, quarks)
K32 Formulate estimates for a wide range of measurements and scales (e.g., angstroms to light years)
K33 Formulate and interpret representations of time from origin to present accounting for phenomena of scale (e.g., smoothness, punctuations, chaos)
K34 Formulate interpretations of the historical development of various theories of possible causes of diversity among physical and biological phenomena (e.g., the works of Aristotle, Mendel, Darwin, McClintock)
K35 Formulate models and hypotheses that can be used to explain the interactions of components within technological and ecological systems

Subunit: Conditions for Learning Science

Competencies:

C1 Participate actively in dialogue about and resolution of community issues
C2 Assess information from various countries in the original language or translated form to ascertain the perspectives of many cultures
C3 Analyze the scientific ideas presented in science fiction stories and films
C4 Perform and repeat investigations to verify data, determine regularity, and reduce the impact of experimental error
C5 Present the results of investigations in a variety of forums
C6 Contribute to the decisions regarding topics for investigation
C7 Use various creative means to communicate interpretations of scientific ideas, concepts, phenomena, and events
C8 Consider the scientific thinking and language of others
C9 Individually and collaboratively produce clearly written representations of investigative results
C10 Fulfill responsibilities as part of a research group
C11 Select and utilize resources by various criteria (e.g., efficiency, effectiveness, health, safety) that are appropriate to the investigations being conducted by groups
C12 Present persuasive argument based on the scientific aspects of controversial issues
C13 Collect, store, retrieve, and manipulate information with available technologies that may range from hand processes up through computer applications
C14 Investigate social issues with a scientific perspective (e.g., human rights, wellness, economics, futurism, environmental ethics)
C15 Keep journals of observations and inferences made over an extended period of time, and reflect upon the impact of these recorded ideas on own thinking and actions
C16 Examine the intellect, perspectives, and ethics of notable scientists
C17 Collect and analyze observations made over extended periods of time and compare these to scientific theories
C18 Create presentations of scientific understandings using diverse modes of expressions
C19 Conduct formal scientific debates in the classroom

C20 Wonder about the likelihood of events that may occur by chance or coincidence
C21 Plan and conduct field trips and experiences for small and large groups
C22 Analyze the historical context that leads to and has led to scientific theories
C23 Seek information on topics of personal scientific interest from a variety of sources
C24 Conduct learner-developed investigations independently and collaboratively over periods of weeks and months
C25 Listen attentively and critically to presentations of scientific information made by others
C26 Conduct analyses of propaganda related to scientific issues
C27 Perform investigations that require observations over varying periods of time
C28 Experience scientific concepts as interpreted by other cultures through multimedia and local and global specialists
C29 Access appropriate technology to perform complicated, time-consuming tasks
C30 Relate historical accounts of science to the cultural context in which they were written
C31 Work as a contributing member of a collaborative research group
C32 Examine the influences of social and political structures and realities that contribute to inquiry about scientific issues
C33 Use technology (e.g., desktop publishing, teleconferencing, networking) to communicate scientific ideas
C34 Explore and analyze a variety of perspectives on science (e.g., works by men and women of many racial, ethnic, and cultural groups)
C35 Lead groups of learners of various ages in designing, planning, and conducting science activities
C36 Respect the scientific thinking of others and self
C37 Recognize and contrast different epistemologies
C38 Develop possible courses of action in response to scientific issues of local and global concern
C39 Determine the validity of research conclusions in relation to the design, performance, and results
C40 Develop multimedia presentations of group and individual research projects and investigations appropriate for a variety of audiences and forums
C41 Produce interesting and scientifically correct stories and present them using various modes of expression
C42 Reflect on the ideas and content found in own journal records
C43 Examine ambiguous results and formulate explanations
C44 Recognize and synthesize the contributions to scientific thought of individuals from many cultures
C45 Construct models and simulations of the component structures and functions of living and nonliving entities
C46 Lead multi-age groups in the examination of and planned resolution for scientific issues
C47 Recognize and choose members of research teams based upon the merit of their ideas and skills
C48 Construct a portfolio of products, documentation, and self-evaluations of own abilities, skills, and experiences
C49 Synthesize scientific information from a variety of sources
C50 Evaluate and prioritize scientific issues based upon risk-benefit analyses
C51 Refine scientific skills from a variety of experiences

Subunit: Applications for Science Learning

Competencies:

A1 Answer student-determined questions by designing databases and drawing inferences from the analyses of the information in these databases
A2 Make personal behavior decisions by interpreting information that has a scientific basis
A3 Propose courses of action that will validate and demonstrate personal understandings of scientific principles
A4 Guide other learners in their understanding of the interactions of technologies and society at various periods in time
A5 Promote and carry out practices that contribute to a sustainable environment

A6 Study and propose improvements in public services and systems in own community
A7 Choose consumer materials utilizing personal and environmental risk and benefit information
A8 Make inferences and draw conclusions using databases, spreadsheets, and other technologies
A9 Do simple troubleshooting on common electrical and mechanical systems, identifying and eliminating possible causes of malfunctions
A10 Construct devices that perform simple, repetitive actions
A11 Investigate the functionality of various geometric shapes in the natural world and the designed world (e.g., translations from spherical to plane representations cause distortions; triangular shapes contribute to rigidity and stability in structures; round shapes minimize boundary for a given capacity)
A12 Make decisions regarding personal and public health
A13 Evaluate the social and ecological risks and benefits resulting from the use of various consumer products
A14 Analyze the contributions of advances in technology through history to own everyday life
A15 Identify and reduce risks and threats to a sustainable environment
A16 Extend the limits of human capabilities using technological enhancements
A17 Use and recognize various propaganda techniques
A18 Solve unique problems using the results of systematic analyses
A19 Choose everyday consumer products that utilize recent innovation and pass appropriate performance criteria
A20 Refine personal career interests through investigations of the diversity of manufacturing, research, service, and invention processes
A21 Predict and investigate the working of toys and tools while controlling and manipulating variables (e.g., friction, gravity, forces)
A22 Write, follow, modify, and extend instructions (e.g., equations, algorithms, formulas, flow diagrams, illustrations)
A23 Create products, make inferences, and draw conclusions using databases, spreadsheets, and other technologies
A24 Predict various scenarios and propose solutions to community issues using scientific information (e.g., actuarial tables, census data, topographic maps, incidence data, climatic data)
A25 Use scientific evidence to consider options and formulate positions about the health and safety of others and self
A26 Search for, use, create, and store objects and information using various strategies and methods of organization and access
A27 Research and write environmental impact statements of own design
A28 Compare school-based science perspectives with those gained through cutting-edge technological applications
A29 Design management plans for natural and human-altered environments (e.g., woodlots, patios, lots, lawns, farmlands, forests)
A30 Refine personal career interests
A31 Promote public awareness of the interaction of technology with social issues
A32 Advocate and propose courses of action for local and global scientific issues using global networks
A33 Use appropriate technologies to prepare and present the findings of investigations incorporating tables, graphs, diagrams, and text
A34 Make informed consumer choices by evaluating and prioritizing information, evidence, and strategies
A35 Develop an informed point of view that allows for validation or refutation of the scientific statements and claims of advocates before pursuing courses of action (e.g., contributing support, signing petitions, casting votes)
A36 Differentiate between observations and inferences in the exploration of evidence related to personal, scientific, and community issues
A37 Develop and write environmental impact, and safety and hygiene management plans
A38 Use technology to collect, analyze, and communicate information (e.g., electronic networks, desktop publishing, remote sensing, graphing calculators, satellite telemetry, and others)
A39 Design, construct, and market inventions

Academic Competencies: Precision Machining Technologies

The Precision Machining Technologies OCAP panel of expert workers (see member list on the inside back cover) identified the following academic competencies (from the total list, pp. 48-62) as most crucial to the entry-level success of an employee in the area of precision machining technologies. It is recommended that these competencies be taught in an applied manner for students enrolled in precision machining technologies programs.

Unit: Communications Skills

Subunit: Reading—Structure

Competencies:

RS1	Exhibit knowledge of language structure
RS5	Develop and use an increasingly sophisticated vocabulary gained through context
RS15	Apply an expanding vocabulary gained through reading

Subunit: Reading—Meaning Construction

Competencies:

RM3	Read to clarify personal thinking and knowledge
RM12	Use reading as a possible problem-solving strategy to clarify personal thinking and knowledge

Subunit: Reading—Application

Competencies:

RA1	Select and read material for personal enjoyment and information
RA7	Extend value of reading, writing, speaking, viewing, and listening by pursuing, through reading, new concepts and interests developed as a result of these activities

Subunit: Reading—Multidisciplinary

Competencies:

RM9	Read to facilitate content learning

Subunit: Writing—Structure

Competencies:

WS3	Locate and correct errors in usage, spelling, and mechanics (e.g., subject-verb agreement, parallel construction, pronoun reference, punctuation, capitalization, sentence structure) using a variety of resources
WS4	Recognize information gained from primary and secondary sources
WS5	Develop writing that contains ordered, related, well-developed paragraphs with sentences of varied lengths and patterns

Subunit: Writing—Meaning Construction

Competencies:

WM3	Respond to others' suggested revisions to a piece of writing (e.g., self-question, re-read, revise)
WM10	Recognize and refine personal writing styles

Subunit: Writing—Application

Competencies:

WA1	Apply appropriate writing techniques (e.g., prewriting, drafting, revising, editing, presenting) suitable for varied writing tasks
WA9	Make judicious use of reference sources (e.g., dictionary, thesaurus, online database, encyclopedia)

Subunit: Writing—Multidisciplinary

Competencies:

WM4	Write in response to reading, speaking, viewing, and listening

Subunit: Listening/Visual Literacy—Structure

Competencies:

LS4	Expand vocabulary through listening to and viewing varied media (e.g., recordings, films, music, news broadcasts)

Subunit: Listening/Visual Literacy—Meaning Construction

Competencies:

LM1	Develop critical thinking skills necessary to evaluate media and assess oral presentations

Subunit: Listening/Visual Literacy—Application

Competencies:

LA1	Listen attentively during oral reading

Subunit: Oral Communication—Structure

Competencies:

OS1	Refine oral communication skills (e.g., voice modulation, eye contact, body language)
OS4	Organize notes and ideas for speaking (e.g., cause-effect, chronological, exemplification)
OS7	Organize notes and ideas for formal, semiformal, and informal presentations of information

Subunit: Oral Communications—Meaning Construction

Competencies:

OM1	Make connections between prior knowledge and new information for oral presentations
OM2	Participate in informal speaking activities (e.g., offering opinions, supporting statements, questions, clarification, entertainment)
OM5	Participate in group communication activities (e.g., debates, panel discussions, negotiations, book-sharing, roundtables, cooperative/collaborative groups)

Subunit: Oral Communications—Multidisciplinary

Competencies:

OM1	Value thinking and language of others

Unit: Mathematics Skills

Subunit: Numbers and Number Relations

Competencies:

NR1	Compare, order, and determine equivalence of real numbers
NR2	Estimate answers, compute, and solve problems involving real numbers

Subunit: Measurement

Competencies:

M1	Estimate and use measurements
M2	Understand the need for measurement and the probability that any measurement is accurate to some designated specification
M9	Construct and interpret maps, tables, charts, and graphs as they relate to real-world mathematics
M11	Understand and solve right triangle relationships as they relate to measurement—specifically those that deal with the Pythagorean theorem
M16	Develop an ability to identify real problems and provide possible solutions
M17	Express and apply different types of measurement scales
M18	Determine area and volume

Subunit: Estimation and Mental Computation

Competencies:

E4	Use mental computation when computer and calculator are inappropriate

Subunit: Data Analysis and Probability

Competencies:

D1	Organize data into tables, charts, and graphs

Subunit: Algebra

Competencies:

A1	Describe problem situations by using and relating numerical, symbolic, and graphical representations
A9	Determine slope, midpoint, and distance
A13	Set up and solve linear equations
A20	Explore geometric basis for functions of trigonometry
A29	Decide whether problem situation is best solved using computer, calculator, paper and pencil, or mental arithmetic/estimation techniques
A37	Simplify algebraic expressions

Subunit: Geometry

Competencies:

G1	Create and interpret drawings of three-dimensional objects
G3	Apply Pythagorean theorem
G4	Demonstrate knowledge of angles and parallel and perpendicular lines
G9	Use deductive reasoning

Subunit: Patterns, Relations, and Functions

Competencies:

P3	Translate among tables, algebraic expressions, and graphs of functions
P8	Apply trigonometric functions to problem situations involving triangles
P10	Explore periodic real-world phenomena using sine and cosine functions
P16	Solve trigonometric equations, and verify trigonometric identities

Unit: Science Skills

Subunit: Scientific Inquiry

Competencies:

Q1	Check the appropriateness and accuracy of measures and computations using various strategies (e.g., estimations, unit analysis, determination of significant figures)
Q3	Translate information from and represent information in various forms with equal ease (e.g., tables, charts, graphs, diagrams, geometric figures)
Q4	Use existing algebraic formulas and create new ones in appropriate problem-solving situations
Q6	Invent apparatus and mechanical tools needed to perform unique tasks in various situations
Q9	Make and read scale drawings, maps, models, and other representations to aid planning and understanding
Q11	Use appropriate units for counts and measures
Q14	Communicate the results of investigations clearly in a variety of situations
Q17	Select, invent, and use tools, including analog and digital instruments, to make and record direct measurements
Q34	Create, standardize, and document procedures
Q40	Draw conclusions based on the relationships among data analysis, experimental design, and possible models and theories

Subunit: Conditions for Learning Science

Competencies:

C25	Listen attentively and critically to presentations of scientific information made by others

Notes

Verification Panels

The Vocational Instructional Materials Laboratory wishes to extend thanks and appreciation to the many representatives of business, industry, labor, and community organizations who donated their time and expertise to the identification and revalidation of competencies.

The following panel was responsible for verifying the occupational competencies on the Precision Machining Technologies OCAP, identifying those academic competencies that an entry-level employee should possess, and determining the Work Keys academic skill levels required for successful entry into the occupation:

Rusty Blake, *W. E. Products*, Salesville, Ohio
Dennis Bondy, *Toledo Molding & Die*, Toledo, Ohio
Michael Davanaugh, *Fredon Corp.*, Mentor, Ohio
Dan Flanagan, *Lee's Grinding, Inc.*, Strongsville, Ohio
Tom Greene, *Greene Tool Systems, Inc.*, Springfield, Ohio
Dennis Kiley, *Kiley Mold and Tool, Inc.*, Fayetteville, Ohio
Dan Musk, *Encore Mfg. Co.*, Cleveland, Ohio
Mike Palitto, *Reuther Mold and Mfg.*, Cuyahoga Falls, Ohio
Rich Toeppe, *Whirlpool Corp.*, Findlay, Ohio
Howard West, *North Dayton Tool & Gauge*, Tipp City, Ohio
Richard Yanus, *Done Right Engine and Machine*, Strongsville, Ohio

The following panel was responsible for verifying the competencies on the Employability OCAP:

Barbara J. Forster, *Nationwide Insurance*, Columbus, Ohio
Joan L. Hall, *Health Management Nursing*, Chesapeake, Ohio
Jane Highland, *Southern Ohio Staffing, Inc.*, Chillicothe, Ohio
Chuck Jackson, *Butech, Inc.*, Salem, Ohio
Garry Kessel, *Medina Auto Parts, Inc.*, Medina, Ohio
Joyce A. McMickens, *Ernst & Young*, Cleveland, Ohio
Julie C. Payeff, *The Andersons Management Corp.*, Maumee, Ohio
Patricia Piper, *Edison Industrial Systems Center*, Toledo, Ohio
Gary F. Rybak, *Red Roof Inns, Inc.*, Hilliard, Ohio